The Canadian Entomologist

Vol. LXXXVI Ottawa, Canada, November 1954 No. 11

A Description of the Larva of *Agriotes mancus* (Say), with a Key Separating the Larvae of *A. lineatus* (L.), *A. mancus*, *A. obscurus* (L.), and *A. sputator* (L.) from Nova Scotia[1]

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In Europe, extensive work on wireworms has revealed taxonomic problems in the genus *Agriotes*. Since the investigations of Roberts (1922) after the First World War it has been possible for both field men and taxonomists to identify the larvae of *A. sputator* (L.), but the problem of separating *A. obscurus* (L.) and *A. lineatus* (L.) has persisted through all subsequent work. The European literature on *Agriotes* larvae deals extensively with the latter problem (Beling, 1883-84; Ford, 1916; Guéniat, 1934; Henriksen, 1911-12; Horst, 1922; Korschefsky, 1941; Mesnil, 1930; Rambousek, 1928; Schaerffenberg, 1943; Subklew, 1934; and Znamenskij, 1927), but none of the authors expresses satisfaction with the characters found.

A. mancus (Say), a native species, and one or more of the three European species are now known to occur together in certain Canadian localities (Eidt, 1953). *A. obscurus* occurs at several localities in the Halifax, Yarmouth, Sydney, and Annapolis Valley areas, at Lunenburg and Lower West Pubnico in Nova Scotia, and at Cobble Hill and Agassiz in British Columbia. *A. lineatus* occurs in the Yarmouth vicinity in Nova Scotia, at St. John's, Nfld., and at Cobble Hill, B.C. *A. sputator* occurs at several localities in the Sydney and Digby-Weymouth areas, at Forest Glade in Nova Scotia, and at Tabusintac, N.B. All these species are causing damage to crops; hence it is important that we be able to distinguish their larvae.

This paper presents a re-description of the mature larva of *A. mancus*[3]; comparisons with *A. obscurus*, *A. lineatus*, and *A. sputator*; and a key to species. The method of description and most terminology is taken from Glen (1950).

For the description of the larva of *A. mancus*, specimens from Dufferin County, Ontario, were used. Since the European species do not occur in Ontario and many *A. mancus* adults were taken from pupal cells in the same field, these larvae were doubtlessly *A. mancus*. Collections of *A. mancus* from Nova Scotia, identified by rearing, were similar. The European species were tentatively identified by locality. Portions of the collections, reared to adults, confirmed the identifications.

The Full-grown Larva of *A. mancus*

General: Elongate, subcylindrical, straw-yellow. Length 19-23 mm., width about 1.6 mm. Identified as belonging to the genus *Agriotes* Esch., *sputator* group (as defined by Glen in 1944), by the absence of urogomphi, the presence of two prominent "eye-like" impressions on the ninth abdominal segment, and the presence of a subapical tooth on the mandible.

Head Capsule: Strongly sclerotized, prognathous. In dorsal view (Fig. 2) subquandrangular, about equal in length and width, sides convex, surface flat-

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3Two previous descriptions by Pettit (1872) and Hawkins (1936) are inadequate by today's standards and in view of the similarity between *Agriotes* larvae of the *sputator* group.

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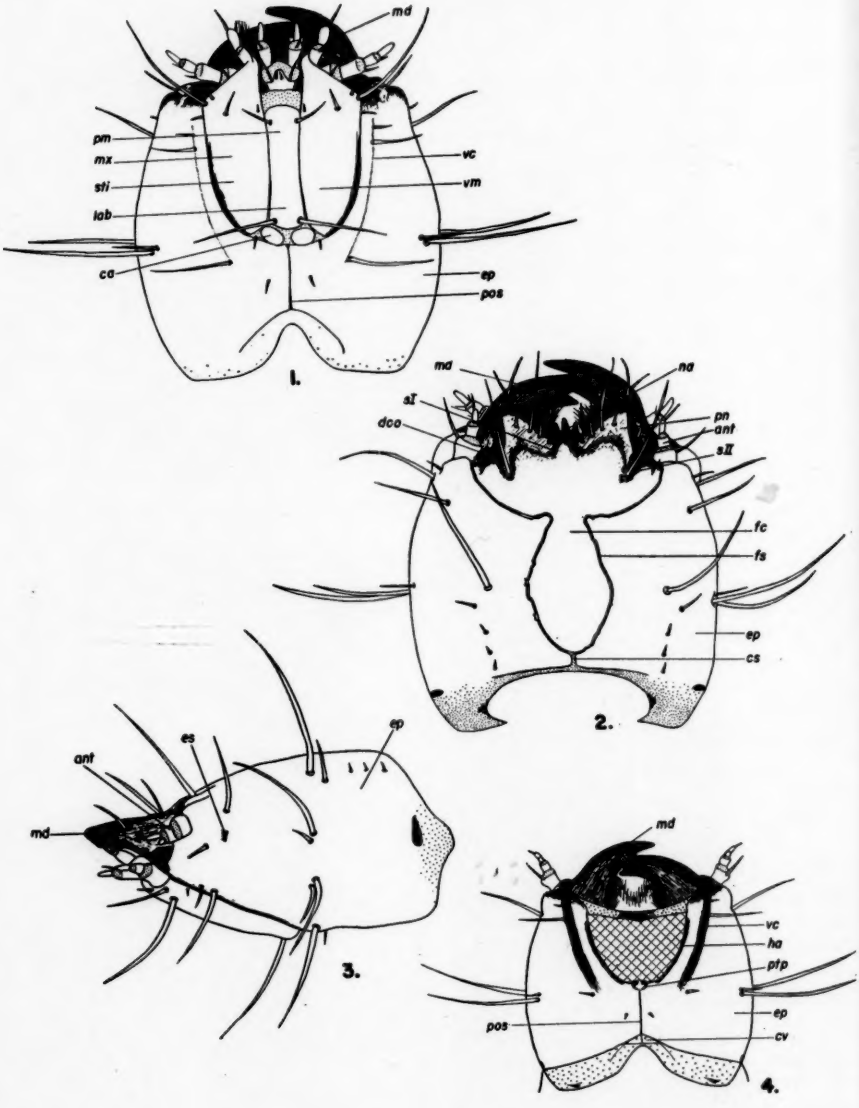


Figs. 1-4. *A. mancus.* 1, Head, ventral. 2, Head, dorsal. 3, Head, lateral. 4, Head, ventral, ventral mouth parts removed. Abbreviations: ant, antenna; ca, cardo; cs, coronal suture; cv, cervical sclerite; dco, dorsal condyle of mandible; ep, epicranial plate; es, eye-spot; fc, frontoclypeus; fs, frontal suture; ha, hypostoma; lab, labium; md, mandible; mx, maxilla; na, nasale; pm, postmentum; pn, paranasal lobe; pos, postoccipital suture; ptp, posterior tentorial pit; sI and sII sulci of the frontoclypeus,; sti stipes; vc, ventral carina of the epicranium; vm, ventral mouth parts.

tened; in situ, covered by prothorax as far anteriorly as bifurcation of epicranial suture. In ventral view, (Figs. 1 and 4) concave for reception of ventral mouth parts (fused labium and maxillae); occipital margin emarginate. In lateral view (Fig. 3), tapered for one-half its length to base of mandible.

Frontoclypeus (fc, Fig. 2) defined by distinct frontal sutures (fs, Fig. 2). Anterior part transverse, bearing setae as in Fig. 2. Posterior part spatulate. Anterior margin mesally bearing tridentate nasale (na, Figs. 5, 6, 7, and 2); median tooth slightly longer than lateral ones. Subnasale (sn, Figs. 5, 6, and 7) ventral to nasale; a row of teeth, variable in number, usually about six. Paranasal lobes (pn, Figs. 6 and 2) longer than nasale, inner margin slightly convex, outer margin slightly concave, median and anterior margins densely pilose. Dorsal mandibular condyle (dco, Fig. 2) lateral to paranasal lobe, broad, arcuate, strongly sclerotized, and pigmented. Dorsal surface with two pairs of sulci, first (SI, Fig. 2) originates between nasale and paranasal lobes, continues caudally as broad, shallow depression, about one-quarter the length of transverse portion of frontoclypeus. The second (SII, Fig. 2) originates between paranasal lobes and dorsal mandibular condyles, continues as broad, shallow depression to large seta on disc of frontoclypeus.

Epicranial plates (ep, Figs. 1, 2, 3, and 4) large, constituting posterodorsal, posteroventral, and lateral parts of head capsule, dorsally meeting at coronal suture (cs, Fig. 2), ventrally at postoccipital sutures (pos, Figs. 1 and 4). Ventral surface with carina (vc, Figs. 1 and 4) extending from base of mandible posteromesally to beyond caudal margin of hypostoma; edges of epicranial plates depressed from ventral carina to hypostomal margin (ha, Fig. 4), forming concavity for reception of united labium and maxillae; hypostoma thickened. Posterior tentorial pits (ptp, Fig. 4) at anterior end of postoccipital sutures. Eye-spot (es, Fig. 3) a subcuticular pigmented spot, lateral, immediately caudad to antenna. Setae as in Figs. 1, 2, and 3, sometimes with additional small setae along ventral carinae.

Gula (gu, Fig. 8) invaginated. Anterior extensions of postoccipital sutures (pos, Fig. 4) coincident along midline, cephalad to posterior tentorial pits (ptp, Fig. 4) at bases of cardines (ca, Fig. 1), forcing invagination of gula.

Tentorium (t, Figs. 8 and 9) reduced; posterior arms only present; posterior part (pt, Figs. 8 and 9) short, acute; anterior part (at, Figs. 8 and 9) well developed, ending freely in cranial cavity near frontoclypeus (fc, Fig. 8).

Antennae (ant, Figs. 10, 11, 2, and 3) three-segmented. Segment I (AI, Figs. 10 and 11) two-thirds as wide as long, as long as II and III combined; ventrolaterally bearing one conspicuous seta, surface with three small pores. Segment II (AII, Figs. 10, 11, and 12) subequal in length and width, less than one-half as long as first; bearing one pore and two or three minute apical setae. "Sensory" appendix (sa, Fig. 12) a lightly pigmented, thin-walled, cone-shaped structure, ventrad to segment III on distal end of segment II. Segment III (AIII, Figs. 10, 11, and 12) one-half as wide as long; distal end bearing one conspicuous seta and several small, probably sensory, setae.

Mandibles (md, Figs. 36, 1, 2, 3, and 4) robust, sickle-shaped, two-thirds as wide as long; triangular in section (Fig. 35). Inner margin with subapical tooth (st, Figs. 36 and 34). Retinaculum (ret, Figs. 36 and 34) equidistant from base and apex of mandible. Penicillus (pen, Figs. 36 and 34) dense, an basal third of inner margin. Dorsal surface bearing one conspicuous seta, one-third the distance from base; base with large socket (soc, Figs. 36 and 35) for reception of dorsal mandibular condyle on frontoclypeus (dco, Fig. 2). Outer side excavate for

reception of antenna; one conspicuous seta a little more than one-half the distance from base. Ventral side flat; large ventral condyle at base (vco, Figs. 35 and 34). Adductor tendon (add, Fig. 36), a large, thin, flat apophysis, arising at median basal angle, 1½ as long as mandible, one-third as wide as long, transparent, bearing small sclerotized area near base. Abductor tendon (abd, Fig. 36) similar, arising from ventrolateral angle near ventral mandibular condyle, 1½ as long as mandible, one-seventh as wide as long, transparent, with small sclerotized area near base.

Ventral mouth parts (vm, Fig. 1) consisting of fused labium and maxillae; move as unit, cephalad and caudad, the cardines acting as hinges.

Maxillae (mx, Fig. 1) well developed. Cardo divided into two sclerites. The lateral sclerite (caI, Fig. 13) elongate, heavy, dark in colour; articulating in socket on hypostoma near posterior tentorial pits; bearing one short seta at anterior end. Mesal sclerite (caII, Fig. 13) oval, larger than lateral one, but not specialized. Stipes (sti, Fig. 1) elongate, subquadrangular, convex, constituting largest part of ventral mouth parts, one-third as wide as long; setae as in Fig. 1. Maxillary palp (mp, Fig. 14) four-segmented; first three segments gradually diminishing in size, subequal in length and width; segment I with two setae and four or five pores; segment II with one pore and four or five apical setae; segment III with two pores and three or four apical setae; segment IV subequal in length to III, width one-half the length. Galea (ga, Fig. 14) two-segmented; segment I three-quarters as wide as long; segment II slightly shorter than first, three-quarters as wide as long, bearing one pore, and apically a number of setae and peculiar "sensory" structures (Fig. 16). Lacinia (la, Fig. 14) reduced, triangular, acute; bearing dense brush of plumose hairs on inner margin.

Labium (lab, Fig. 1) consists of postmentum and prementum. Postmentum (pm, Fig. 1) elongate, subquadrangular, 3½ as long as wide; bearing large spine at both apical and both basal angles. Prementum (prm, Fig. 15) subquadrangular, three-quarters as wide as long; ventral surface with two large setae and two small setae, sometimes one or two setae between anterior two; dorsal side with pile of plumose hairs. Ligula (lig, Fig. 15) reduced, lightly sclerotized; bearing two conspicuous setae, sometimes more. Palps (lp, Fig. 15) two-segmented; segment I one-half as wide as long, bearing three or four pores and apically four or five setae; segment II three-fifths as long as first, one-third as wide as long.

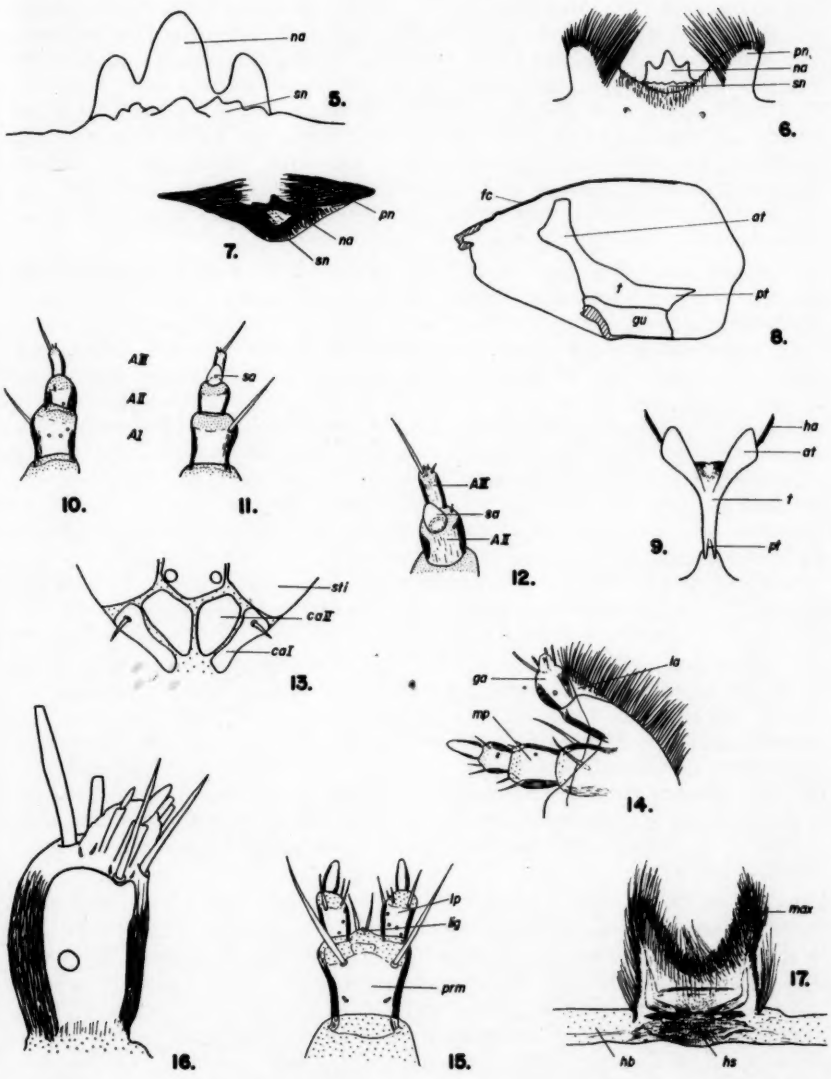
Hypopharynx (Fig. 17) with transverse basal sclerome (hs); joined to hypostoma by pair of strong braces (hb). Maxillulae (max) acute. Hypopharynx, excepting hypopharyngeal sclerome and brace, clothed with dense forward projecting pile of plumose hairs.

Epipharynx pilose with plumose hairs.

Cervical region. Only evidence of cervical sclerites is two weakly sclerotized areas on ventral side (cv, Fig. 4); each bears minute seta. Cervical membrane bears two minute setae, each in line with dorsal epicranial row of setae. Stippled portion of posterior margin of head in Figs. 1, 2, 3, and 4 is invaginated, and provides muscle insertions.

THORAX: (Figs. 18 and 19). Each segment slightly wider and thicker than preceding one; terga sparsely and very shallowly punctate.

Prothorax (thI, Figs. 18 and 19) nearly as long as meso- and metathorax combined, slightly longer than wide. Tergum divided into three sclerites; anterior and posterior margins membranous, longitudinally striate. Mediotergite (mtg, Fig. 18) with distinct mediodorsal suture; dorsal impressions as found in many species of elaterid larvae, very vague, linear; setal arrangement constant as in Fig. 18. Laterotergites (ltg, Figs. 18 and 19) narrowed cephalad; each bearing



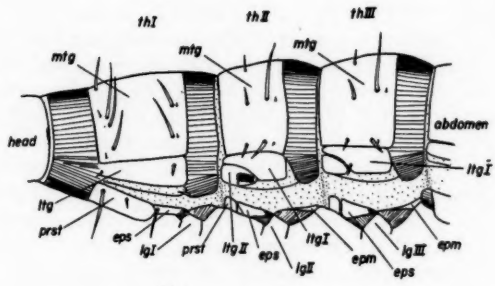
Figs. 5-17. *A. mancus*. 5, Nasale and subnasale, ventral. 6, Epistomal margin, ventral. 7, Epistomal margin, anterolateral. 8, Tentorium, lateral, showing outline of head capsule. 9, Tentorium, dorsal. 10, Left antenna, dorsal. 11, Left antenna, ventral. 12, Distal segments of right antenna, ventral. 13, Proximal portion of ventral mouth parts, ventral. 14, Apex of right maxilla, ventral. 15, Apex of labium, ventral. 16, Apex of right galea, ventral. 17, Hypopharynx, ventral. Abbreviations: AI, AII, and AIII, antennal segments; at, anterior part of posterior arm of tentorium; caI and caII, sclerites of cardo; fc, frontoclypeus; ga, galea; gu, gula; ha, hypostoma; hb, hypopharyngeal brace; hs, hypopharyngeal sclerome; la, lacinia; lig, ligula; lp, labial palp; max, maxillula; mp, maxillary palp; na, nasale; pn, paranasal lobe; prm, prementum; pt, posterior part of posterior arm of tentorium; sa, "sensory" appendix; sn, subnasale; sti, stipes; t, tentorium.

one seta at each end. Membrane slightly darker ventral to laterotergites, suggesting secondary sclerotization or three more laterotergites. Sternum reduced to one large sclerite, the presternum (prst, Figs. 18 and 19); anterior margin membranous, longitudinally striate; setae as in Fig. 19, occasionally with as many as two more along each lateral margin. Episternum (eps, Fig. 19) large, subtriangular; posterior angle with conspicuous condyle for articulation with coxa; anterior angle with one conspicuous seta. Epimeron (epm, Fig. 19) reduced, fused with striated, lightly sclerotized portion of membrane that supports the coxa (b, Fig. 19). Membrane supporting coxa with two weakly sclerotized, striated areas (a and b, Fig. 19).

Mesothorax (thII, Figs. 18 and 19) two-thirds as long as wide. Tergum divided into five sclerites; posterior margin membranous, longitudinally striate. Mediotergite (mtg, Fig. 18) with distinct mediodorsal suture; dorsal impressions very vague, linear; setal arrangement constant. Laterotergites 4, two on each side. First (ltgI, Figs. 18 and 19) elongate, narrowed anteriorly; setae absent. Second (ltgII, Figs. 18 and 19) oval, bearing one spiracle and usually one small seta ventral to spiracle. Membrane slightly darker ventral to first laterotergite, suggesting secondary sclerotization or another laterotergite. Spiracle (sp, Figs. 18 and 19) biforous, 2⅓ as long as broad, larger than abdominal spiracles. Presternum (prst, Figs. 18 and 19) reduced, three sclerites; lateral sclerites each with two minute setae, lateral seta in membrane slightly anterior to sclerite. Episternum (eps, Figs. 18 and 19) subtriangular, without setae; posterior angle with conspicuous condyle for articulation with the coxa. Epimeron (epm, Figs. 18 and 19) elongate, distinct; without setae. Membrane supporting coxa with two weakly sclerotized, striated areas, as in prothorax (a and b, Fig. 19).

Metathorax (thIII, Figs. 18 and 19) slightly larger than mesothorax, similar. Tergum divided into five sclerites; posterior margin membranous, longitudinally striate. Mediotergite (mtg, Fig. 18) similar to that of mesothorax; setal arrangement constant. Laterotergites four, two on each side. First (ltgI, Figs. 18 and 19) similar to that of mesothorax, bearing one seta on ventral margin, one-third the distance from anterior margin. Second (ltgII, Figs. 18 and 19) similar in shape to that of mesothorax, smaller, without spiracle or seta. Sternum similar to that of mesothorax; both minute setae of lateral presternal sclerites are on the sclerites.

LEGS: (Figs. 25, 26, and 27) similar, well developed. Coxa (cox) excavate on dorsal surface for reception of trochanter and femur; anterior surface with 10 to 18 short, stout, dark setae; posterior surface with four to seven short, stout, dark setae, one long slender one and variable number of minute ones. Trochanter (tr) two-thirds as long as coxa; dorsal surface short; ventral long, convex; anterior surface with five to seven short, stout, dark setae; posterior surface with three to six short, stout, dark setae, and one long, slender one; ventral surface with two long, slender setae, the more distad, longest. Femur (fe) sub-cylindrical, subequal in length to coxa, two-thirds as wide as long; anterior surface with five to seven short, stout, dark setae; posterior surface with three to five short, stout, dark setae; ventral surface with one long, slender seta at distal end; dorsal surface with three or four small setae at apical end, and one small seta slightly less than one-half the distance from base to apex. Tibiotarsus (tt) cylindrical, one-half as wide as long; ventral side with two to five short, stout, dark setae; outer side with three slender setae in transverse row, equidistant from base and apex; apex with transverse row of five setae on outer side. Ungula (un) well developed, dark, curved, as long as tibiotarsus; inner side near base with pair of slender setae.



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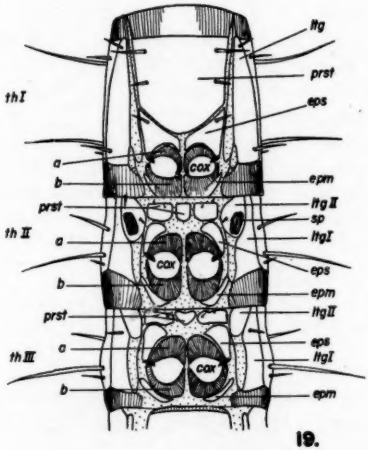

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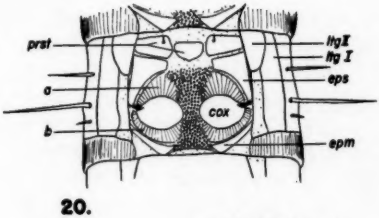

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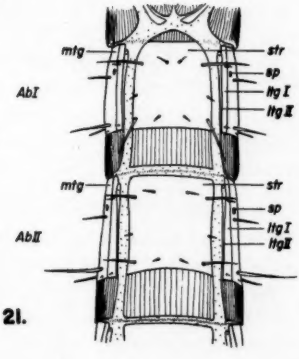

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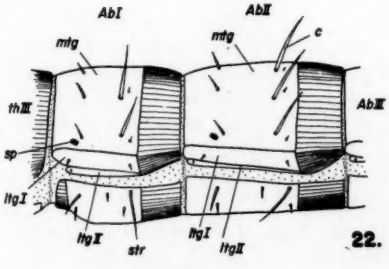

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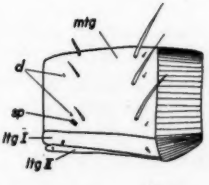

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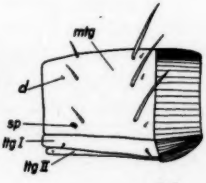

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Figs. 18-24. 18, *A. mancus*, thorax, lateral. 19, *A. mancus*, thorax, ventral. 20, *A. sputator*, metathorax, ventral. 21, *A. mancus*, abdominal segments I and II, ventral. 22, *A. mancus*, abdominal segments I and II, lateral. 23, *A. obscurus*, tergum of abdominal segment II, lateral (*A. sputator* is similar). 24, A. lineatus, tergum of abdominal segment II, lateral. Abbreviations: a and b, secondary sclerites supporting the coxa; AbI, etc., abdominal segments; c, seta (note its absence on AbI); cox, coxa; epm, epimeron; eps, episternum; lg, leg; ltgI and ltgII, laterotergites; mtg, mediotergite; prst, presternum; sp, spiracle; str, sternum; thI, thII, and thIII, thoracic segments; trg, tergum.

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ABDOMEN: Approximately 3½ times as long as thorax, cylindrical, pointed apically; terga sparsely and very shallowly punctate.

First to eighth abdominal segments similar, each segment slightly longer than wide except first (AbI, Figs. 21 and 22), as wide as thick. Mediotergites (mtg, Figs. 21 and 22) with mediodorsal suture present; posterior margin longitudinally striated; dorsal impressions very vague, linear; setae on mediotergites of segments II to VIII as on segment II (AbII, Fig. 22); segment I with one seta of posterior row (c, Fig. 22) absent. Spiracle (sp, Figs. 21 and 22) biforous, in anteroventral angle of mediotergite. First laterotergite (ltgI, Figs. 21 and 22) elongate, at least five times as long as wide; posterior margin longitudinally striated; one small seta near each end. Second laterotergite (ltgII, Figs. 21 and 22) elongate, much narrower than first; small dark structure of unknown significance near anterior end. Pleurites absent. Sternum (str, Figs. 21 and 22) quadrangular, two-thirds as wide as long; posterior margin longitudinally striated; anterior margin on first segment arcuate, longitudinally striate; setae as in Fig. 21.

Ninth abdominal segment about 1½ as long and subequal in width to segment VIII, slightly greater than one-half as wide as long; sides arcuate; apex pointed. Tergum (trg, Figs. 28 and 29) with subovate "eye-like" impressions (em) on dorsal surface; four shallow, longitudinal impressions (im, Fig. 28) (external expressions of internal points of muscle attachment) on dorsal surface, two of which originate from posterior margin of "eye-like" impressions; setae as in Figs. 28 and 29, sometimes with other small setae present, but not consistently so. Pleural area (pl. Fig. 29) membranous, dorsoventrally striated. Sternum (str, Fig. 29) less than one-half length of whole segment, arcuate caudally, with a transverse row of six to eight setae.

Tenth abdominal segment (AbX, Fig. 29) borne on sternum of segment IX; short, tubular; bearing eight setae, without armature; anal aperture longitudinal, slit-shaped, median.

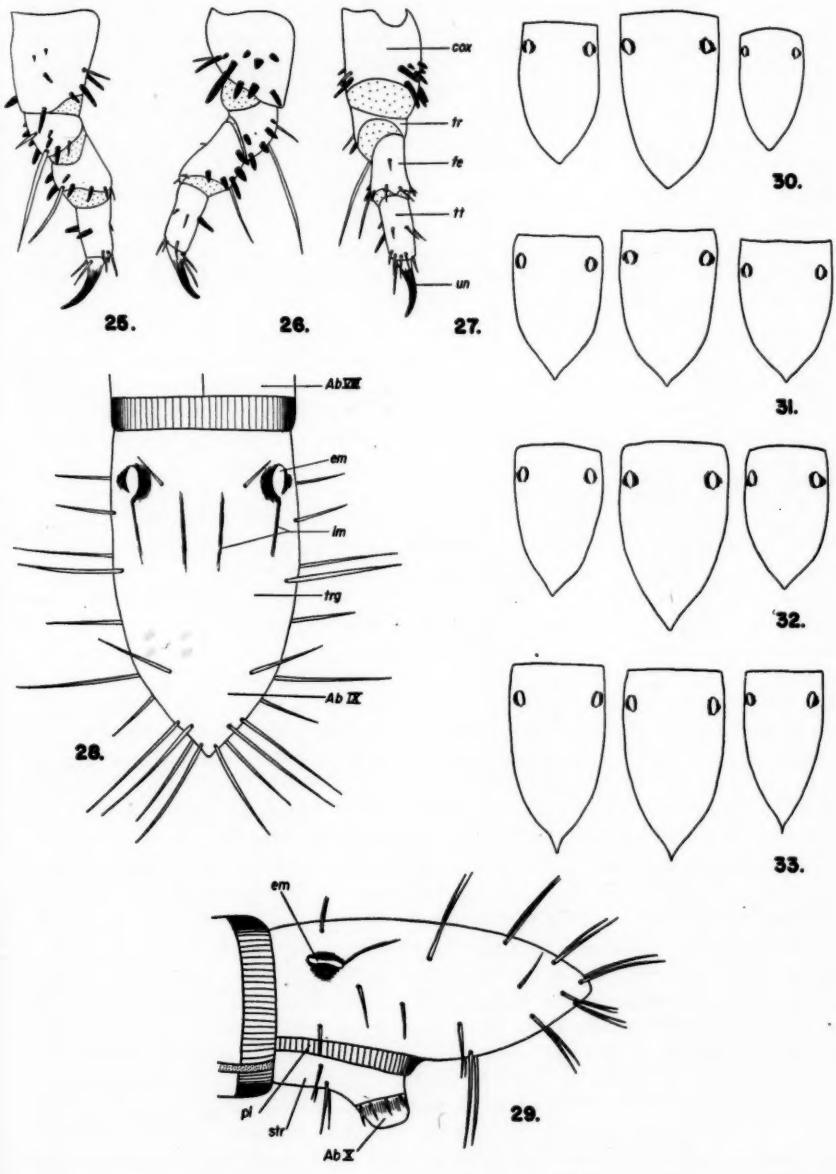
A Comparison of the Introduced European *Agriotes* spp. with *A. mancus*

GENERAL: *A. obscurus*, *A. lineatus*, and *A. sputator* fit the foregoing description very closely. *A. sputator* is smaller, the full-grown larva being about 16 mm. long. Practically every pore and seta is present in the same position as in *A. mancus*. The nasale, one of the most useful structures in wireworm taxonomy, is similar in all four species.

Frontoclypeus. Guéniat (1934) made an excellent extensive study of the first stadium larvae of *A. lineatus* and *A. obscurus*. He found very slight variations in the shape of the frontoclypeus. "A la longue cependant et après en avoir examiné des dizaines, on arrive dans le 40% des cas environ à distinguer les jeunes larves de *lineatus* par le frontal, dont la boucle est en général plus étroite." Statistical treatment of data from 50 larvae of each species failed to support Guéniat's observation.

Mandibles. Guéniat (1934) found that the shape of the retinaculum varied somewhat between the first stadium larvae of *A. lineatus* and *A. obscurus*. Many intergrades occur, and the character is consequently of little value.

Znamenskij (1927) first drew attention to differences in the shape of the subapical tooth of the mandible. The literature is somewhat confused on this character. Schaerffenberg (1943) said Znamenskij found an angle of 60° with the longitudinal axis of the mandible for *A. obscurus* and 30° for *A. lineatus*. Znamenskij described the angle with the apex of the mandible as obtuse in *A. obscurus*, acute in *A. lineatus*, and right-angled in *A. sputator*. This agrees with his drawings, but the figures he gave are 60°, 30°, and 45°. Subklew



Figs. 25-33. 25-29, *A. mancus*. 25, Prothoracic leg, posterior. 26, Prothoracic leg, anterior. 27, Prothoracic leg, dorsal. 28, Abdominal segment IX, dorsal. 29, Abdominal segments IX and X, lateral. 30-33, Outline drawings of series of abdominal segments IX, dorsal. 30, *A. mancus*. 31, *A. lineatus*. 32, *A. obscurus*. 33, *A. sputator*. Abbreviations: AbVIII, etc., abdominal segments; cox, coxa; em, "eye-like" impressions; im, dorsal impressions; fe, femur; pl, plueron; str, sternum; tr, trochanter; trg, tergum; tt, tibiotarsus; un, ungula.

(1934) checked Znamenskij's measurements and got values of 110° to 120° for *A. obscurus*, 60° for *A. lineatus*, and 90° for *A. sputator*. Guéniat (1934) quoted Subklew's measurements. It is not certain whether they made any measurements of their own. Korschefsky (1941) made measurements and found 110° to 120° for *A. obscurus* and 60° for *A. lineatus*. Van Emden (1945) gave 110° to 120° for *A. obscurus*, but gave a range of 60° to 90° for *A. lineatus*.

In Figs. 37 to 40 series of mandibles are figured. These were selected for minimum erosion by examining the nasale and mandibles. Unfortunately, all of the available specimens of *A. sputator* were eroded to some degree, Fig. 40B showing the least wear.

The nearest figure to the actual angle should be that of the smallest angle in each series. This angle is about 90° for *A. obscurus*, 70° for *A. lineatus*, 60° for *A. sputator*, and about 40° for *A. mancus*.

It is striking that these data should vary so much from those of European workers, although Guéniat (1934, p. 267), who presented the most impressive paper dealing with these species, had little faith in the character. Variations in the data must certainly be due to the extreme difficulty in measuring the angles. There is a physical difficulty of measurement, a personal difficulty of establishing the angle to be measured, and an unavoidable erosion factor.

The four series of mandibles figured segregate into distinct groups. The most striking variant is that of *A. mancus*. The angle is decidedly different from those of *A. obscurus* and *A. lineatus*. The latter are the two species most difficult to distinguish from *A. mancus* on other characters.

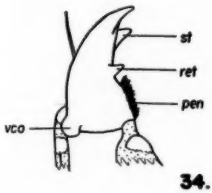
THORAX: The thoraces of *A. lineatus*, *A. obscurus*, and *A. sputator* fit the foregoing description quite well. There are, however, a few differences, one of which is important.

Prothorax. *A. sputator* differs from the rest in the form of the membranous area between the coxal cavities (Mesnil, 1930). This region, which Mesnil calls "le bourrelet tégumentaire" bears a profusion of darker spots resembling flagstones. These spots gradate into the weakly sclerotized areas that support the coxa (a and b, Fig. 20), which were noted on *A. mancus* (a and b, Fig. 19). The sclerites supporting the coxa are less clearly defined in *A. sputator*. The episternum and epimeron are not as distinctly defined in *A. sputator*.

Measurements were taken of the length and width of the prothorax in 50 specimens of each species. Statistical treatment of the measurements, as ratios, revealed no significant differences between species.

Mesothorax. The seta borne by the second laterotergite (ltgII, Fig. 19) is absent in *A. sputator*. Roberts (1928) pointed out that the thoracic spiracle of *A. lineatus* is one-third longer than that of *A. obscurus* and slightly wider. He also noted that the teeth along the sides of the orifices number 80 to 96 in *A. lineatus* and 47 to 50 in *A. obscurus*. The character is not well founded on the basis of the material at hand, *A. sputator* differing more from *A. obscurus* than *A. lineatus* does. Mesnil (1930) suggests that Roberts examined a spiracle of *A. sputator* rather than *A. lineatus* by mistake. Subklew (1934) considered the dimensions of the spiracles and the number of teeth along the orifices useless characters for distinguishing *A. lineatus* and *A. obscurus*.

Measurements of the lengths and widths of the thoracic spiracles of the four species indicate a similarity between *A. lineatus* and *A. obscurus*. This is contrary to the findings of Roberts. *A. mancus* is similar to *A. obscurus* and *A. lineatus*, but the thoracic spiracles of *A. sputator* are longer in relation to their width. The approximate ratio of length to width is 2 for *A. lineatus*, 2⅓ for



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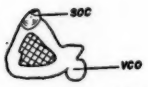

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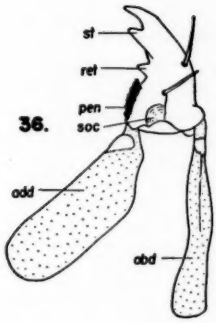

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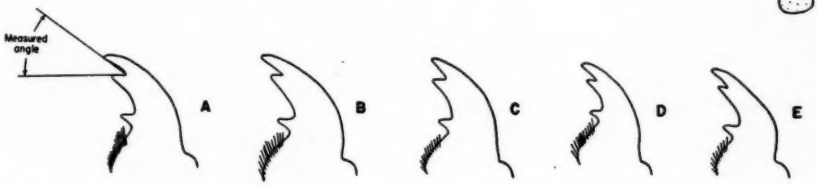

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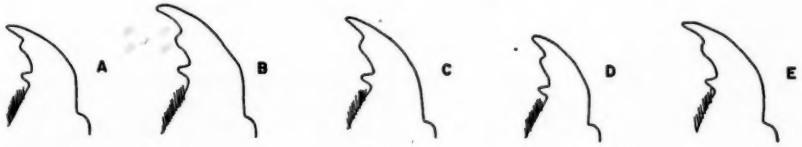

38.

39.

40.

Figs. 34-40. 34-36, *A. mancus*, right mandible. 34, Ventral. 35, Cross section. 36, Dorsal. 37-40, Outline drawings of series of right mandibles. 37, *A. mancus*. 38, *A. obscurus*. 39, *A. lineatus*. 40, *A. sputator*. Abbreviations: abd, abductor tendon; add, adductor tendon; pen, penicillus; ret, retinaculum; soc, socket for reception of dorsal mandibular condyle; st, subapical tooth; vco, ventral mandibular condyle.

A. mancus and *A. obscurus*, and 3 for *A. sputator*. The measurements were taken from the outer limits of the peritreme as shown in Roberts' drawings (p. 93). The length was measured parallel to the longitudinal axis of the orifices; the width perpendicular to it.

The episternum and epimeron are similar, but less definite in *A. sputator*. The striated secondary sclerites which bear the coxae differ in *A. sputator* as in the prothorax, with the dark spots again evident. Only one minute seta was visible on each of the lateral sclerites of the sternum in *A. sputator*. The other may have been indistinguishable because of the smaller size of the larvae of this species.

Metathorax. The seta borne by the first laterotergite (ltgI, Fig. 18) is absent in *A. sputator*. The episternum and epimeron are similar, but less definite in *A. sputator*. The striated secondary sclerites are as in the mesothorax. The dark spots are shown in Fig. 20. The sterna bear minute setae as in the mesothorax.

LEGS: The setae borne on the legs are quite variable in number but similar in position throughout the four species and on all three pairs of legs. No distinguishing characters have been found.

ABDOMEN: The abdomens of *A. lineatus*, *A. obscurus*, and *A. sputator* differ little from that of *A. mancus* although a few differences of limited value as key characters exist.

Setae. The setae on the mediotergites of the first eight abdominal segments vary in number. In all four species each of the setae in the posterior row has a minute seta near its base, as in Fig. 22. In *A. mancus* none of the anterior row of setae has a minute seta at its base (Fig. 22). In *A. obscurus* and *A. sputator* the lateral two setae of the anterior row have a minute seta at each of their bases (d, Fig. 23). In *A. lineatus* the innermost lateral seta of the anterior row has a minute seta at its base (d, Fig. 24). This character held for 59 specimens of *A. mancus*; 39 out of 48 specimens of *A. sputator*; 32 out of 40 specimens of *A. lineatus*; and 42 out of 47 specimens of *A. obscurus*, with one having the same arrangement as *A. lineatus*. This character is quite usable, even if the stadium is advanced. If the small setae are seen on either side of *any* of the segments I to VIII, they should be considered present. The small setae are difficult to see on small larvae, but on the species having them they can usually be found on all but the smallest.

Punctation. The punctation of *A. sputator* is not the same as that of *A. lineatus* and *A. obscurus* (Roberts, 1928) nor that of *A. mancus*, but this is a difficult character to evaluate. The anterior portion of the tergum of the second and third thoracic and first to ninth abdominal segments of *A. sputator* bear smaller, more closely spaced punctures than the rest of the segment. The transition is abrupt and is apparent just cephalad to the anterior row of setae (Roberts, 1922).

Spiracles. The spiracles of *A. sputator* are longer in proportion to their width than those of the other three species. The approximate ratio of length to width is 2½ for *A. sputator* and 1¾ for the others. The abdominal spiracles were measured in the same manner as those of the thorax.

Ninth abdominal segment. The apex of the ninth abdominal segment is usually blunter in *A. mancus* (Fig. 30) and very acute in *A. sputator* (Fig. 33). *A. lineatus* (Fig. 31) and *A. obscurus* (Fig. 32) are similar, and intermediate between *A. mancus* and *A. sputator*. This character is useless for differentiation, due to difficulty in defining it, and intergradation between species. Furthermore,

the segment is usually not perfectly symmetrical. Schaerffenberg (1943) suggested differences in the overall shape of the ninth abdominal segment for distinguishing *A. lineatus* from *A. obscurus*. No difference is evident with the material at hand. Schaerffenberg also pointed out that the "eye-like" impressions are nearer the base of the segment in *A. obscurus* than in *A. lineatus*. Statistical treatment of data obtained on the length and width of the segment, and the distance of the "eye-like" impressions from the anterior margin in 50 specimens of each of the four species, failed to reveal any significant differences.

CHROMOSOMES: S. G. Smith, Forest Insect Laboratory, Sault Ste. Marie, Ont., has studied the chromosomes of these four species, using gonadial material from fall-collected adults (personal communication). His findings are summarized here.

All four species have nine pairs of autosomes. *A. sputator* has an Xy sex-determining mechanism, the y chromosome being very small. *A. obscurus*, *A. lineatus*, and *A. mancus* have an XO sex-determining mechanism, with the X chromosome of *A. mancus* permanently associated with the nucleolus. *A. sputator* is probably the most primitive since it retains the small y chromosome and thus conforms to the type taken to be basic for Coleoptera as a whole. *A. mancus* is probably the most recent since the behavior of the nucleolus is atypical. Smith pointed out that it is possible he obtained more than one species under the label "*sputator*" since there was appreciable size difference between the y chromosomes of different individuals.

Key to the Larvae of *Agriotes lineatus*, *A. mancus*, *A. obscurus*, and *A. sputator*

A. Sternal area between the coxae with small, distinct, brownish-yellow juxtaposed plates (Fig. 20); terga of meso- and metathoraces and abdomen with anterior margin (i.e., area anterior to spiracles and setae) more finely, densely punctured than rest of segment; spiracles long and narrow, thoracic spiracles three times as long as wide, abdominal spiracles 2½ times as long as wide ..... *Agriotes sputator* (L.)

AA. Sternal area between the coxae without distinct plates (Fig. 19); terga of meso- and metathoraces and abdomen with anterior margin sculptured similarly to rest of segment; thoracic spiracles less than 2½ times as long as wide, abdominal spiracles 1¾ as long as wide ..... B

B. Subapical tooth of the mandible, when uneroded, forming an angle of 60° or greater with the inner margin of the apex (Figs. 38 and 39); minute seta[4] usually present in front of one or both of inner and outer lateral setae of anterior row of abdominal mediotergites II to VIII (d, Figs. 23 and 24) C

BB. Subapical tooth of mandible, when uneroded, forming an angle of approximately 40° with the inner margin of the apex (Fig. 37); minute setae[4] absent (Fig. 22) ..... *Agriotes mancus* (Say)

C. Minute seta[4] usually present in front of each of inner and outer lateral setae of anterior row of abdominal mediotergites II to VIII (d, Fig. 23); subapical tooth of the mandible, when uneroded, forming an angle of 90° or greater with the inner margin of the apex (Fig. 38) ..... *Agriotes obscurus* (L.)

CC. Minute seta[4] usually present only in front of the innermost lateral setae of anterior row of abdominal mediotergites II to VIII (d, Fig. 24); subapical tooth of the mandible, when uneroded, forming an angle of less than 90°, but greater than 60° with the inner margin of the apex (Fig. 39) ..... *Agriotes lineatus* (L.)

[4]If present on either side of any of abdominal segments I to VIII they are to be considered present.

Acknowledgments

The assistance of the graduate committee, particularly Dr. W. E. Heming, Chairman, is gratefully acknowleged. Special recognition is due Professor A. W. Baker for his interest in the work.

A. mancus larvae from Ontario were supplied by Mr. J. A. Begg. In the absence of the author, field work in Nova Scotia was looked after by Mr. C. J. S. Fox. Mr. W. J. Brown and Dr. E. C. Becker checked the adult determinations.

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(Received July 20, 1954)

New Records and New Synonymies for North American Leafhoppers (Homoptera: Cicadellidae)[1]

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In this paper records are given for three species of leafhoppers described from Europe and not recorded previously for North America, and six names that have been applied to North American species are reduced to synonymy with the names of species described from Europe.

Doliotettix pallens (Zett.)

Fig. 1

Cicada pallens Zetterstedt, 1828: 157.
Thammotettix lapponicus Haupt, 1931: 157.

This species has not been recorded previously for North America. One male from "Gov. R.R.", Alaska, J. M. Aldrich Collection, now in the United States National Museum, was identified and sent to me for examination by Dr. D. A. Young, with whose permission it is recorded. The genus *Doliotettix* has not been definitely recorded for North America. Oman's (1949) "*Doliotettix*" is apparently another genus, possibly undescribed.

The forms of the aedoeagus and of the male pygofer are distinctive. The female seventh sternite was figured by Ossiannilsson (1947). A moderate-sized insect, 5.9 mm. in length; yellow with three pairs of weak brownish spots on the vertex; forewing hyaline brownish-yellow with the costa yellow.

Psammotettix lapponicus (Oss.)

Fig. 2

Deltocephalus lapponicus Ossiannilsson, 1938: 4.

This species, which was described from specimens collected in Sweden, has not been recorded previously for North America. Three males were collected at Chesterfield, Northwest Territories, in August, 1950, by J. R. Vockeroth. They were compared with Swedish specimens.

Length 2.5-2.8 mm. Stramineous, with heavy brown markings on the vertex and pronotum and fuscous markings between the veins of the forewing. On the basis of external characters it cannot be distinguished reliably from other species of the genus. No reliable differences were found between females that may be of this species and females of *P. lividellus* (Zett.) collected in the same locality on the same dates. The form of the aedoeagus is distinctive, though close to that of *P. revae* Knull.

Psammotettix confinis (Dahlb.)

Fig. 3

Deltocephalus confinis Dahlbom, 1850: 193.
?*Deltocephalus harrimani* Ashmead, 1904: 132. New synonymy.
Deltocephalus theni Edwards, 1915: 208.
Deltocephalus spathifer Rebaut, 1925: 19.

This European species has not been recorded previously for North America. It is possible that it is conspecific with *P. harrimani* (Ashm.). No specimens labelled *harrimani* were found in the collection of the United States National Museum. One of two specimens collected by the Harriman Alaskan Expedition, and now in that collection, was examined. It bears the label "*Deltocephalus haldemani.* ♂ type. Ashm." Ashmead did not describe a species under that name and it is probable that the specimen may be of the species described by him

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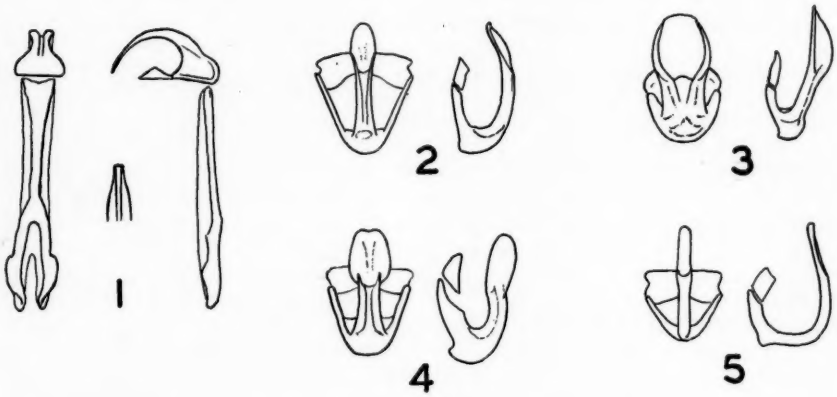

Figs. 1-5. Male genitalia cf: 1, *Doliotettix pallens* (Zett.); 2, *Psammotettix lapponicus* (Oss.); 3, *P. confinis* (Dahlb.); 4, *P. alienus* (Dahlb.); 5, *P. lividellus* (Zett.).

as *harrimani*. However, the data attached to the specimen of *haldemani* examined give the date of capture as July 21, whereas Ashmead (1904) gave the date of capture of *harrimani* as July 7. DeLong (1926) quoted, and agreed with, Osborn's opinion that *harrimani* was "evidently *affinis*" [i.e., *lividellus*], but at that time the taxonomic importance of the internal male genitalia was not appreciated fully and this synonymy seems to have been based on external characters only, and therefore cannot be regarded as definite. Though it is probable that *harrimani* is a synonym of *confinis* it is impossible to arrive at a positive conclusion at present.

Length 3.0 mm. Stramineous, with well-developed dark markings on the vertex and pronotum and fuscous streaks between the veins of the forewings. It cannot be distinguished reliably from other species of *Psammotettix* on the basis of external characters, but the form of the aedoeagus is distinctive. The female was not available for examination.

Psammotettix alienus (Dahlb.)

Fig. 4

Thammotettix aliena Dahlbom, 1850: 187.
Deltocephalus breviceps J. Sahlberg, 1871: 342. *Nec* Kirsch.
Deltocephalus latipex DeLong and Davidson, 1935: 70. New synonymy.
Deltocephalus striatus, var. *breviceps* Ossiannilsson, 1937: 133. *Nec* Kirsch.
Laevisephalus striatus DeLong and Knull, 1945: 40. *Nec* Linn. New synonymy.
Psammotettix striatus DeLong, 1948: 258. *Nec* Linn. New synonymy.

This species was described as *latipex* when the name *striatus* was applied to *lividellus* in North America. The species treated by European workers as *striatus* is distinct from the American species on characters of the internal male genitalia, though the two species are obviously closely related. The species treated by European workers as *striatus* has not been found in North America.

This species appears to have a mainly northerly and westerly distribution, though DeLong and Knull (1945) and Oman (1949) indicate that it occurs also in the central and northeastern regions. Specimens were examined from localities in British Columbia, northern Manitoba, Northwest Territories, and Washington. The species has been reliably recorded from Colorado and Nebraska.

***Psammotettix lividellus* (Zett.)**

Fig. 5

Cicada lividella Zetterstedt, 1840: 290.
Deltocephalus affinis Gillette and Baker, 1895: 84. New synonymy.
Deltocephalus striatus Sanders and DeLong, 1920: 8, DeLong, 1926: 81, and Osborn, 1928: 284. *Nec* Linn. New synonymy.
Laevicephalus striatus DeLong and Davidson, 1935: 168. *Nec* Linn. New synonymy.
Psammotettix striatus DeLong, 1948: 258. *Nec* Linn. New synonymy.

Cicada lividella was described from specimens collected in Greenland. It was subsequently recorded from Scandinavia and Finland but these records proved erroneous. The species wes redescribed and the genitalia were illustrated by Ossiannilsson (1938). Though the abdomens are missing from the types in Zetterstedt's collection, there can be no doubt that Ossiannilsson's interpretation is correct. Nothing in the appearance of the types contradicts this, and *lividellus* is the only species of *Psammotettix* found in Greenland, where it has been captured by a number of collectors. Specimens collected there in 1948 (Ossiannilsson Collection) and 1952 (Canadian National Collection) were examined and are identical in genitalic and other characters with the widely distributed North American species referred to by writers in North America as *affinis* or *striatus*.

Gillette and Baker described *affinis* from one female collected in Colorado. Though the description and illustrations may apply to some other species of the genus, it seems most probable that Gillette and Baker had *lividellus* as it is the most common species of the genus. The species treated by European workers as *striatus* has not been found in North America.

This is one of the most widely distributed of North American leafhoppers. Specimens were examined from numerous localities in Alberta, British Columbia, Labrador, Manitoba, Northwest Territories, Ontario, Quebec, and Saskatchewan, and from localities in Alaska and Greenland. The species has been reliably recorded from localities in California, Colorado, Illinois, Iowa, Kansas, Maine, New Hampshire, New Jersey, New York, Ohio, and Utah. It appears to be the only species of leafhopper that is common in the Arctic; specimens have been collected, often in numbers, at such Arctic localities as Port Harrison, Quebec; and Chesterfield, Lake Harbour on Baffin Island, and Kilduit Bay, Richards Island, Northwest Territories; and in Alaska and Greenland.

***Pinumius areatus* (Stal)**

Deltocephalus areatus Stål, 1858: 193.
Deltocephalus sexmaculatus Gillette and Baker, 1895: 88. New synonymy.

This synonymy was suggested by Oman (1949). The North American species, which has been found in Colorado, British Columbia, and Saskatchewan, is conspecific with *aeratus*, which is found in northern and central Europe and in Siberia.

***Cazenus xanthoneurus* (Fieb.)**

Deltocephalus xanthoneurus Fieber, 1869: 219.
Deltocephalus canadensis DeLong, 1926: 71. New synonymy.
Laevicephalus cicatrix DeLong and Sleesman, 1929: 102. New synonymy.

The North American species previously referred to as *Cazenus cicatrix* is conspecific with the European species *Deltocephalus*, or *Sorhoanus*, *xanthoneurus*. No differences are apparent between the female of *cicatrix* and the holotype female, in the Canadian National Collection, of *Deltocephalus*, or *Mocuellus*, *canadensis*.

Acknowledgments

The author wishes to express his thanks to Professor D. M. DeLong, Ohio State University, Dr. Frej Ossiannilsson, Uppsala, Sweden, and Dr. David A.

Young, Jr., Entomology Research Branch, United States Department of Agriculture, for the loan of specimens or other assistance. Much of the material studied of the genus *Psammotettix* was collected in the Northern Insect Survey, a joint project of the Entomology Division, Department of Agriculture, and the Defence Research Board, Department of National Defence.

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A New Pyralid of Palaearctic Affinities from Colorado (Lepidoptera)[1]

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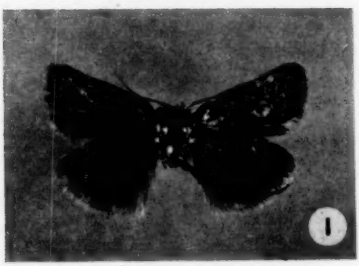
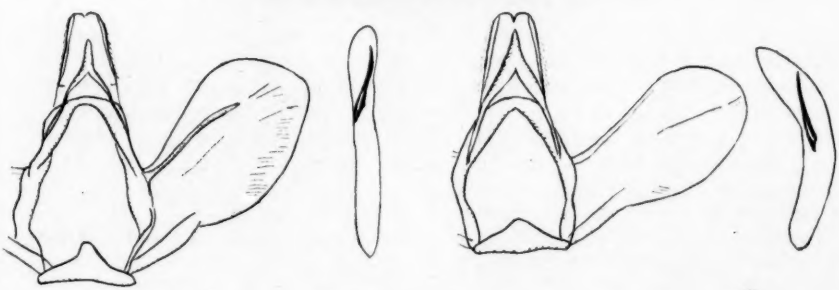
The genus *Metaxmeste* Hübner [1824-25] was erected for four nominal species. There was no original type designation, and so far as I know there has been no subsequent one; accordingly, I designate *Pyralis phrygialis* Hübner as type. This species, though included in *Titanio* Hübner by most authors, differs from *normalis* Hübner, the type of *Titanio*, in the less prominent frons, in lacking specialized setae on the dorsal surface of the antenna, and in having Sc+R completely free from R_s in the hind wing. I consider these characters to be of generic importance.

Metaxmeste phrygialis is well known in Europe but nothing similar has ever been recorded from America. I was therefore astonished to find, in material





Figs. 1-2. *Metaxmeste nubicola.* 1, holotype, ♂, x 2. 2, ♂ genitalia, juxta omitted.
Fig. 3. *Metaxmeste phrygialis.* ♂ genitalia, juxta omitted.

collected by Prof. A. B. Klots in Colorado, two specimens of an obviously related species. The Colorado specimens differ from *phrygialis* in maculation and structure, and represent an undescribed species.

Metaxmeste nubicola, new species

Figs. 1, 2

Male: robust, hairy, with wings rounded, costa of fore wing highly arched just beyond base. Head, body, and upper side of wings dark silky grey, hind

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wing somewhat duller than fore wing. Fore wing above with reniform and orbicular spots and transverse posterior line faintly indicated as slightly paler markings. Hind wing above with costal area a little paler than the rest. Both wings beneath light grey suffused with darker in and behind the cell. Fore wing with reniform and regularly curved subterminal, both markings dark and rather obscure. Both wings above and beneath with a dark terminal line followed by a long paler fringe.

This species differs in maculation from *M. phrygialis* in the darker fringe of the hind wing, in the more extensive and less definitely margined dark suffusion of the fore wing beneath, and in lacking the transverse posterior line of the hind wing beneath. The frons is more prominent and oblique than in *phrygialis*. The male genitalia differ from those of *phrygialis* (Fig. 3) in having the valve broader, with a much stronger subcostal fold, and in having the gnathos shorter, with the distal part less strongly tapered than the basal part.

Holotype, ♂, and allotype, ♀, Hall Valley, Park Co., Colo., "Arctic Alpine zone 'tundra'", altitude 11,500-12,500 feet, 13-15 July, 1935, collector A. B. Klots. Types ex coll. A. B. Klots in the American Museum of Natural History.

(Received July 9, 1954)

Book Notice

THE ODONATA OF CANADA AND ALASKA, by Edmund M. Walker, Professor Emeritus of Zoology, University of Toronto. Honorary Curator of Zoology, Royal Ontario Museum of Zoology and Palaeontology. xi + 292 pp. 44 pls. University of Toronto Press. 1953. Price $13.00.

For half a century the author of this work has been occupied as a part-time activity, with the observation, collection and study of the dragonflies of Canada, and from his wealth of experience in this field he has drawn the materials which constitute the present volume. In it he brings together much information from his previous writings and from those of his contemporaries, and also adds many new observations from his field notes and laboratory studies. The work is presented as a faunistic study, the first part of the volume consisting of a general treatise on the order Odonata, and the second of a detailed account of the suborder Zygoptera. A second volume, now in course of preparation, will deal exclusively with the remainder of the Odonata—the suborder Anisoptera.

In the volume at hand the general account of Odonata is divided into two sections, the first dealing with the external structure of the adult dragonfly and the full-grown nymph, and the second with the life history and habits of dragonflies. The structural descriptions are comprehensive and the illustrations are ample, but excessive detail is avoided, the author preferring to refer the reader to the literature for information of this nature. Important variations in structure, however, are carefully noted, especially where they have been used extensively in taxonomy or, as often in the nymph, where they are correlated with a particular habitat or mode of life. The section covering the life history and habits of dragonflies is necessarily a condensation of a very large and diversified subject. Nevertheless, in 26 pages, the author has given an account of the salient features of dragonfly biology, arranging his information under the series of topics: habitats, habits of adults, developmental stages, enemies of dragonflies, and parasites. Further detailed information on these matters is given elsewhere in the

text under the heading "Field Notes", which form an important part of the accounts of most species.

Part II, which makes up the greater part (pp. 59-278) of the volume, consists of a detailed account of the species of Zygoptera of Canada and Alaska. Fifty-one species are included, which number, the author notes, is somewhat less than half the total number known from North America north of Mexico. The species are contained in 11 genera belonging to 3 families: Agriidae (2 genera, 4 species), Lestidae (1 genus, 9 species) and Coenagriidae (8 genera, 38 species). Keys to adults and nymphs are provided for the recognition of the species and the higher groups, and elsewhere these are more fully characterized. For the most part, the classification is straightforward, but in the difficult *Enallagma* section of the family Coenagriidae the author points out the need for further studies to clarify the generic arrangement. He notes, in particular, that in the nymphs of this group there are characters that appear of generic value, but that these do not always correspond to the adult features that have been used in defining the genera. This, he states, has made it impossible to construct a practical key to all the recognized genera based on nymphal characters. One source of trouble is found in the genus *Enallagma*, which, he states, is a composite group requiring generic subdivision. He does not consider present knowledge sufficient to do this, but he offers some helpful groupings of the Canadian species based on a combination of adult and nymphal characters.

For each species a full description, usually with illustrations, is given for the adult male and female, and the full-grown nymph where the latter is known. The detailed descriptions of females and nymphs add much to the value of the work, inasmuch as these forms have not, in general, been as precisely described by previous workers. Habitat and range for each species are given, and detailed information is included on the distribution in Canada and Alaska. Under most species the author gives extensive field notes, in which he includes a variety of observations on the species. In an easy, conversational style he discusses such matters as distribution, abundance, seasonal occurrence, mating and oviposition habits, and nymphal and adult habitats, with a familiarity that bespeaks many years of patient and careful investigation and observation in the field. Many new facts are recorded and new subjects for investigation are suggested, thus making this portion of the work especially valuable for future students and collectors. The volume concludes with a selected bibliography and an index.

Students of Odonata are familiar with the high quality of workmanship in the author's previous publications on the order. His monographic studies on the North American species of *Aeshna* and *Somatochlora* are well known and serve as models for this type of systematic work. In a like manner the present volume sets a high standard and will well repay examination by all workers engaged in the preparation of faunistic studies on other groups of insects.

G. STUART WALLEY

Bark Beetles of the Genus *Carphoborus* Eichhoff (Coleoptera: Scolytidae) in North America[1]

By STEPHEN L. WOOD[2]

The genus *Carphoborus* is widely distributed in the Holarctic realm. It occurs from the northern limits of tree growth south in the Old World to India and northern Africa and in the New World to Baja California, New Mexico, Mississippi, and Florida.

All of the North American species breed in the inner bark of coniferous trees of the genera *Pinus*, *Picea*, and *Pseudotsuga*. Branches that are being shaded out or are broken, but still hanging in the tree, are generally preferred for the construction of galleries. A few species have been reported from slash; however, they are usually not aggressive or abundant enough to survive in competition with other bark beetles normally found in slash. The economic importance of the genus is not great; the habit of breeding in the unthrifty lower branches of coniferous trees contributes slightly toward accelerating the natural pruning of the trees and consequently aids in the production of a higher quality of timber.

The breeding habits of *Carphoborus* spp. do not differ greatly from those of many other polygamous scolytid beetles. The burrows are constructed partly in the inner bark and partly in the sapwood. The burrow consists of a short entrance tunnel that leads to a rather large nuptial chamber and several egg galleries. The entrance tunnel is usually on the lower side of the branch and slopes upward as it enters the bark. The nuptial chamber is engraved in the sapwood rather deeply; it is rather large, at least four millimeters in width and six millimeters in length. About five to eight egg galleries radiate from the nuptial chamber; each egg gallery is usually lined on both sides by large, deep, closely spaced egg niches. An egg is deposited in each niche and is carefully packed in with boring dust that evidently is mixed with a secretion from the female parent. The larval mines extend out from the egg galleries; they are ordinarily rather short and without a definite pattern, often doubling back and crossing one another. The egg galleries are engraved in the sapwood rather deeply, usually to a depth equivalent to at least two-thirds of their diameters. The larval mines are almost entirely in the inner bark and often do not touch the sapwood.

The winter is passed as mature larvae and young adults. These become sexually mature in the spring or early summer, when the males emerge to seek a new host. Several days, or weeks later the females emerge to join the males. Normally about five females are associated with each male, although as many as nine have been observed. As with other polygamous species, the male is ordinarily found in the nuptial chamber and the females in the egg galleries; they commonly remain in these positions until death. Mating generally occurs at the junction of an egg gallery and the nuptial chamber; it evidently occurs repeatedly.

Intraspecific Variation

Secondary sexual characters of the frons are conspicuous in all species of *Carphoborus*. The frons of the female is flattened, rarely concave or convex, whereas that of the male is usually rather strongly impressed on the lower half and bears a transverse, bituberculate, median elevation at the upper margin of

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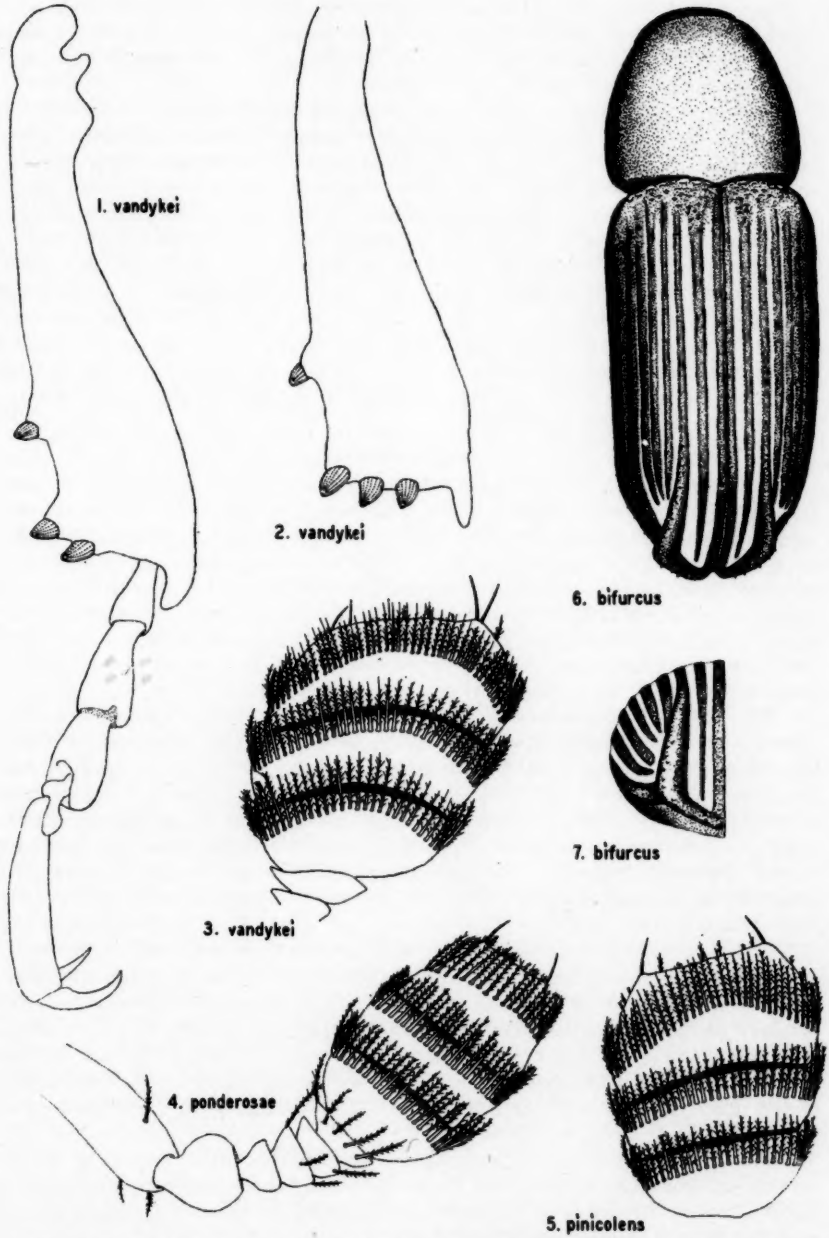


Figs. 1-7.—*Carphoborus* spp.: 1, *vandykei*, outline of posterior aspect of fore tibia and tarsus; 2, *vandykei*, outline of anterior aspect of hind tibia; 3, *vandykei*, anterior face of antennal club; 4, *ponderosae*, anterior face of antennal club; 5, *pinicolens*, anterior face of antennal club; 6, *bifurcus*, subdorsal aspect (vestiture and punctures of striae and interstriae omitted); and 7, *bifurcus* caudal aspect of left elytron (vestiture and punctures of striae and interstriae omitted).

the impression. The frontal vestiture of the female is usually much longer and more abundant than that of the male. In most species of the genus, the scales on the pronotum are more slender in the female; and in some species the elytral scales appear to be more abundant in the male.

Individual variation is usually not conspicuous, except the sculpturing of the elytral declivity. In certain individuals of some of the more primitive species, particularly *blaisdelli* and *vandykei*, the declivital serrations of the alternate interspaces are entirely absent. In other species, the number and spacing of the serrations vary slightly. The width of the second declivital interspace is used several times in the systematic section to separate species; unfortunately, occasional individuals vary sufficiently that they could be assigned to the wrong species unless it is possible to associate them with long series of specimens. In those species with rather weakly elevated declivital interspaces, the slight variation in the height of the elevations may be greater between certain specimens of a series than between certain individuals of different species, and yet the average difference between the two species is sufficient to separate them when used in combination with other differences.

Geographic Variation

Geographic variation was found in three species. Specimens of *ponderosae* from British Columbia have the frontal elevation of the male greatly reduced or absent, and the female frons usually has a narrow median groove; specimens from Utah and Wyoming always have a well developed frontal elevation in the male and lack a median groove in the female. Females of this species from series collected in Oregon have the frons slightly impressed and the declivity less coarsely sculptured, suggesting the beginning of a cline between typical *ponderosae* and *radiatae;* at present, it is interrupted by a gap in their known distributions.

The declivital sculpture of *pinicolens* is not as coarse in specimens from Oregon and northern California as in those from other parts of its range. Specimens of *vandykei* from British Columbia are more finely sculptured than those from California. The *pinicolens* specimens from Oregon are almost indistinguishable from California specimens of *vandykei*, but at any given locality the slight differences between the species are maintained. In addition to variation in the declivital sculpture, the frontal pubescence of females of *pinicolens* gradually decreases in length (about 20 per cent) toward the northeastern part of its range.

Discussion of Characters

Interspecific variation in structures on the frons of the female is extremely useful in classification of the genus. It varies from concave in *radiatae* to rather strongly convex in *convexifrons* and *pseudotsugae;* the surface may be shining, with the punctures either uniformly distributed or peripheral, or densely granulate. In the male, variations are less obvious, but the transverse impression of the frons varies in depth, and the median elevation above the impression may be tuberculate or not, or entirely absent.

The antennal club is of considerable importance in determining phylogenetic relationships. It may be large and broad with arcuate sutures as in *blaisdelli* and *vandykei* (Fig. 3), or small and rather slender with straight sutures as in *ponderosae* (Fig. 4) and *bifurcus.*

In outline the pronotum may have the sides subparallel on the basal two-thirds with one or two lateral constrictions, or the sides may be evenly arcuate (Fig. 6). The median line is usually narrowly elevated and conspicuous in the species with a large antennal club; it is inconspicuous in other species. The

punctures of the pronotum are rather coarse in one or two species and rather fine in a few others, but in general this variation is useful only when specimens are compared directly. The scales of the pronotum are almost hairlike in *frontalis;* usually they are small and rather slender, except in *carri* and *bifurcus*, where they are larger and broad.

The discal striae and interspaces are about equal in width in all of the North American species except *carri* and *bifurcus*, in which the striae are much wider than the interspaces. The sculpture of the declivity (Figs. 6 to 31) provides the most useful characters for separating species. The declivital interspaces are equally convex and serrate in some species; specialized elevations and serrations occur in others. The crenulations at the elytral bases and the tibial armature vary slightly, but characters provided by these structures are not reliable enough to be useful in separating species.

Phylogeny

The genus *Carphoborus* is very closely allied to *Polygraphus*, and in some respects the two genera intergrade. These genera differ from all other Holarctic scolytid genera in lacking pronotal asperities, and having a bituberculate frontal elevation in the male (occasionally absent in *Carphoborus*), a deeply emarginate or completely divided eye, the basal margins of the elytra crenulate, and a particular type of tibial armature (Figs. 1, 2). They form a distinct group in the Holarctic Scolytidae but appear to be allied to several of the hylesinine genera of tropical Asia.

Carphoborus and *Polygraphus* undoubtedly descended directly from a common ancestral stock. The principal specializations that have occurred in *Carphoborus* appear to be the partial fusion of the frontal tubercles of the male, complete loss of a segment in the antennal funicle, enlargement of the strial punctures, and modifications of the declivity by the addition of elevations and teeth; those of *Polygraphus* appear to be complete division of the eye into two parts by emargination, only partial loss of the sixth segment in the antennal funicle (Swaine, 1918, p. 55), and the complete loss of sutures in the antennal club.

In an effort to determine the probable characteristics of the ancestral stock, 11 species of *Polygraphus* and 24 of *Carphoborus* were examined. Surprisingly, the characteristics of one of these species, *Carphoborus boswelliae* (Stebbing) (from India), meet the requirements of the author's conception of the hypothetical ancestor almost as completely as did the original product of his imagination. In this species the female frons is similar to that of *carri;* the eye is more shallowly emarginate than is usual for *Carphoborus;* the antennae resemble those of *pinicolens;* the pronotum resembles that of *Polygraphus* more closely than that of *Carphoborus;* the elytral bases are coarsely crenulate as in *Carphoborus;* the strial punctures are very small and shallow as in *Polygraphus;* the interstriae are rather coarsely punctured as in *Carphoborus;* the declivity is broadly, evenly rounded, with minute interstrial tubercles resembling those of many *Polygraphus;* the tibiae are similar to those of *Carphoborus* but resemble more closely those of certain hylesinine genera of southeastern Asia. The body is very stout, much more so than in any of the known species of *Carphoborus* or in the species of *Polygraphus* examined, and the small median frontal elevation of the male is undivided.

The summary of primitive and specialized characters (Table 1) which evidently indicates evolutionary trends within the genus was based on the comparison of characters found in *Carphoborus* spp. with the primitive and specialized characters found in other genera of bark beetles, and on the association

of primitive or specialized characters known to be primitive or specialized in other genera.

TABLE 1

A summary of primitive and specialized characters found in the genus *Carphoborus*

Primitive	*Specialized*
Frontal impression of male rather deep, with a transverse bituberculate elevation above the impression	Frontal impression of male shallow, the median elevation small or absent
Female frons flat, impunctate at centre, pubescence moderately long	Female frons convex or concave, punctate or granulate over entire surface, pubescence very long or short
Antennal club large, broad, the sutures arcuate	Antennal club small, narrow, the sutures straight
Pronotum finely punctured	Pronotum coarsely punctured
Strial punctures small	Strial punctures large
Declivital interspaces equal in width, not elevated, the serrations fine, sparse, uniserate	Some declivital interspaces elevated, others constricted or obsolete, the serrations coarse, abundant, confused
Scales small, narrow	Scales large, broad, appearing multi-lamellate

Until more is known of the Palearctic species, as well as some Nearctic ones, a discussion of the evolution of species within the genus is unwarranted. Some of the North American species appear to be more closely related to Eurasian species than to other American species. For the present, the phylogenetic relationships are considered to be essentially as presented in the key to the species below, the most outstanding exception being that *simplex* should be placed nearer the end of the first major subdivision rather than near the beginning.

Methods

During this investigation more than 2,000 specimens of *Carphoborus* spp. were examined, including the types of all of Swaine's species and the type of *simplex* Leconte. Bruck's types of *cressatyi*, *vandykei*, and *swainei* were not seen, but paraypes of both sexes of these species were examined. Type material of *bifurcus* Eichhoff and *bicristatus* Chapuis was not available.

Illustrations were prepared with the aid of an ocular grid; those of antennae and tibiae were made from Canada balsam slide preparations, and those of elytra from pinned specimens. The strial punctures and pubescence were omitted from illustrations of the elytral declivity (Figs. 6-31) in an attempt to reduce the confusion of these structures with those considered more important in the classification of the group. Figs. 1-5 were drawn to one scale, Figs. 6 and 7 to another and slightly smaller scale than those in Figs 8 to 31. Drawings of the antennae were made with the aid of a phase contrast microscope.

Carphoborus Eichhoff

Carphoborus Eichoff, 1864, Berlin. Ent. Zeit. 8: 27; Leconte, 1868, Trans. Amer. Ent. Soc. 2: 172; Leconte, 1876, Proc. Amer. Philos. Soc. 15: 383; Chapuis, 1869, Synopsis des Scolytides, p. 40 (1873, Mem. soc. roy. sci. Liége, ser. 2, 3: 248); Eichhoff, 1880 (1881), Die europäischen Borkenkäfer, p. 129; Reitter, 1895, Verh. Ver. Brunn 33: 56; Hagedorn, 1910, Ipidae, *in* Wytsman, Genera Insectorum, fasc. 111. 62, Reitter, 1913, Wien. Ent. Zeit. 32: 56; Blatchley and Leng, 1916, Rhynchophora of North Eastern America, p. 660; Swaine, 1918, Canada Dept. Agr. Ent. Br. Bull. 14: 56; Blackman, 1922, Mississippi Agr. Expt. Sta. Tech. Bull. 11: 48; Bruck, 1936, Bull. Southern California Acad. Sci. 35: 111; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 126; Pfeffer, 1941, Sborn, Ent. Odd. Zemsk. Mus. Praze 19: 169; Balachowsky, 1949, Faune de France 50: 147.

History

The genus *Carphoborus* was described by Eichhoff (1864, p. 27) to contain a single species, *Hylesinus minimus* Fabricius. Since that time 24 species, 14 from

Eurasia and north Africa and ten from North America, have been added to the genus. Seven more North American species are described as new in this paper. The unique combination of characters has made recognition of the genus easy; consequently it has not been confused with other genera in the literature. Reitter (1913, p. 56) divided the genus, erecting the subgenus *Estenoborus* for *C. perrisi* Chapuis; however, this division has not been accepted generally by subsequent authors.

Original keys to the North American species have been given by Leconte (1876, p. 383), Swaine (1918, p. 56), and Bruck (1933, p. 105; 1936, p. 111). Leconte's key contained only three species and Swaine's only five. Bruck's keys contained names of all the species known at that time; however, about half of them were known to him only through descriptions or misidentifications.

Description of the Genus

Length 1.4-3.0 mm., about 2.3 times as long as wide; body colour yellowish or brownish-black to black, mouth-parts and tarsi yellow; mouth-parts ornamented with abundant, long yellow hair.

Frons of female usually flattened, rarely concave or convex, coarsely punctured at least at sides and above; pubescence usually consisting of rather long yellow hair; frons transversely impressed in male, usually with a pair of subcarinate, basally fused tubercles at upper margin of the impression. Eye reniform, about 2.3 times as long as wide; narrowly, deeply emarginate on inner line; rather coarsely granulate. Antennal funicle five-segmented, slightly longer than scape; club flattened, with three straight or slightly arcuate, transverse sutures conspicuously marked by rows of setae, the first two sutures septate.

Pronotum about 1.2 times as wide as long, widest near base; sides arcuately convergent, usually with a prominent lateral constriction behind the broadly rounded anterior margin; side and basal margins rounded, not marked by an elevated line; surface closely, rather coarsely punctured, densely clothed with small erect scales.

Elytra about 1.7 times as long as wide; sides subparallel on basal two-thirds, moderately rounded behind; basal margins slightly elevated and armed with about nine coarse, overlapping crenulations, a few submarginal crenulations present, especially on second interspaces; striae slightly impressed, coarsely, closely, rather deeply punctured; interspaces closely punctured, often subgranulate. Declivity moderately steep, usually with alternate interspaces elevated and serrate. Pubescence consisting of small, abundant, erect interstrial scales, and small, inconspicuous, fine strial hair. Scutellum not visible from above. Anterior coxae contiguous; tibiae armed on outer margins with three or four teeth; third tarsal segments cylindrical, not dilated or emarginate.

Type species: Hylesinus minimus Fabricius, monobasic.

Key to the North American Species of *Carphoborus*

1. Antennal club (Fig. 3) large, broad, less than 1.2 times as long as wide; female frons impunctate and glabrous on a rather large median area; transverse impression of male frons more conspicuous and extensive, the median elevation rather large and prominent 2

   Antennal club (Fig. 4) small, narrow, 1.3 or more times as long as wide; female frons punctate or granulate, and pubescent over entire surface; male frons usually less strongly impressed below, the median elevation smaller, often absent 8

2. Female frons flattened and with pubescence long 3

   Female frons convex and with rather short pubescence 6

3. Declivital interspace two as wide as one and three (Figs. 8, 9), usually convex; declivital interspaces one, three, five, seven and nine less strongly elevated, more finely or not at all serrate; California, in *Pseudotsuga macrocarpa* (p. 509) ..... *blaisdelli*

Declivital interspace two distinctly narrower than one or three (Figs. 10-15), flat; alternate declivital interspaces usually more strongly elevated, the serrations usually larger 4

4. Antennal club smaller, narrower; second interspace becoming obsolete on upper half of declivity (Figs. 14-15); third declivital interspaces more strongly elevated; California, in *Pinus* spp. (p 513) ..... *simplex*

Antennal club larger, broad; second declivital interspaces narrow, but continuing to near apex; third declivital interspaces only slightly elevated 5

5. Sutures of antennal club suboblique, rather strongly arcuate (Fig. 3); third and ninth declivital interspaces usually less strongly elevated, the serrations smaller, less abundant; in *Pseudotsuga taxifolia* (p. 510) ..... *vandykei*

Sutures of antennal club subtransverse, nearly straight (Fig. 5); third and ninth declivital interspaces usually more strongly elevated, the serrations larger, more abundant; in *Pinus* spp. (p. 512) ..... *pinicolens*

6. Impunctate area of female frons smaller, not more than one-third as wide as distance between eyes; pronotum more finely punctured; declivity more finely sculptured; in *Picea pungens* (p. 514) ..... *brevisetosus*

Impunctate frontal area of female one-half as wide as distance between eyes; pronotum more coarsely punctured; declivity more coarsely sculptured; in *Pinus* spp. 7

7. Second declivital interspaces continuing to apex; female frons less strongly convex, with rather long pubescence; southern California (p. 515) ..... *frontalis*

Second interspaces becoming obsolete on upper half of declivity (Fig. 16); female frons more strongly convex, with pubescence very short; southern Arizona and New Mexico (p. 516) ..... *convexifrons*

8. Ninth declivital interspaces not elevated or serrate behind declivital base (Figs. 26-31); declivital elevation ending at junction of interspaces three and nine 9

Ninth declivital interspaces regularly serrate and usually elevated from declivital base to junction with interspace three, the elevation usually continuing from this junction to interspace one (Figs. 18-23) 11

9. Third declivital interspaces more strongly, broadly elevated, the serrations small, confused, more abundant on sides of the elevation than on its summit (Figs. 30, 31); Eastern Canada (p. 518) ..... *dunni*

Third declivital interspaces less strongly elevated, narrower, the serrations larger, confined to summit; western 10

10. First declivital interspaces more strongly elevated, rather coarsely serrate (Figs. 26, 27); elevation of third interspaces highest near middle of declivity; Alberta to Utah (p. 517) ..... *sansoni*

First declivital interspaces slightly elevated, finely serrate (Figs. 28, 29); elevation of third declivital interspaces highest near apex; Northwest Territories to Alaska (p. 518) ..... *andersoni*

11. Female frons flattened or concave, rather coarsely punctured; declivital teeth on third interspaces very coarse, longer than height of the interspace (Figs. 20-23); declivital interspaces two, four, six, and eight never serrate 12

Female frons flattened or convex, punctate or granulate; declivital teeth fine, those on third interspace much shorter than height of the elevation; even-numbered declivital interspaces sometimes serrate 13

12. Frons of female broadly concave, very coarsely punctured; male frons with a prominent median tuberculate elevation; declivital interspaces one, three, and nine less strongly elevated, the teeth less numerous and smaller (Figs. 20, 21); California (p. 520) ..... *radiatae*

Frons of female flattened, often with a small, very narrow, deep median groove, punctures not as coarse; male frons usually without a tuberculate elevation; declivital teeth more numerous and larger (Figs. 22, 23); British Columbia to Utah (p. 521) *ponderosae*

13. Declivital interspaces four, six and eight finely serrate; female frons at least weakly convex, finely granulate, never shining and punctured; western 14

Declivital interspaces four, six, and eight not serrate; female frons flattened and punctured, or convex and granulate 15

14. Second declivital interspaces rather broad, serrate (Fig. 17); female frons evenly, weakly convex (p. 522) ..... *declivis*

Second declivital interspaces very narrow, not serrate (Fig. 18); female frons rather strongly produced above the transverse epistomal impression (p. 522) ..... *pseudotsugae*

15. Discal striae about as wide as interspaces; declivital interspaces four, six, and eight subtuberculate (Fig. 19); female frons rather coarsely punctured; frontal pubescence longer and more abundant (p. 523) ..... *intermedius*

Discal striae much wider than interspaces; even-numbered declivital interspaces not subtuberculate; female frons with shorter pubescence 16

16. Female frons flattened, shining, rather finely, closely punctured, the pubescence longer, fine, less abundant; third declivital interspaces moderately elevated (Figs. 24, 25); interspaces five and seven fusing apically; Alberta to New Brunswick (p. 524) ..... *carri*

Female frons convex, opaque, finely granulate, the pubescence short, abundant; third declivital interspaces very strongly elevated, the elevation curving after converging with interspace nine and continuing to sutural apex (Fig. 6, 7); interspaces five and seven ending separately; southeastern U.S. (p. 525) ..... *bifurcus*

Carphoborus blaisdelli Swaine

Figs. 8, 9

Carphorborus blaisdelli Swaine, 1924, Can. Ent. 56: 234; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 131.

Carphoborus cressatyi Bruck (new synonymy), 1936, Bull. Southern California Acad. Sci. 35: 36, 113; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 129.

This species is very closely allied to *vandykei* and *pinicolens* but has declivital interspace two broad, as wide or wider than one or three, and usually convex; and has declivital interspace three usually less strongly elevated. Also, the declivital teeth are smaller than in *pinicolens*.

Female.—Length 1.9-2.2 mm., 2.25 times as long as wide.

Frons flattened, with epistomal region transversely elevated, epistomal margin medially produced (variable) in front of mandibles; surface reticulate, impunctate on a subcircular median area the diameter of which equals about one-fourth the distance between eyes, punctures deep and close surrounding this area; pubescence arising from punctured area fine, rather long. Antennal club 1.04 times as long as wide; sutures suboblique and arcuate as in *vandykei*.

Pronotum 1.2 times as wide as long; sides almost subparallel on basal half, converging slightly anteriorly, laterally constricted just behind the broadly rounded anterior margin; surface reticulate, punctures of moderate size, rather close, deep; median line usually distinctly elevated on middle third; vestiture consisting of abundant small, slender, erect scales.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind, basal margins elevated and armed with about nine large overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae as wide as striae, weakly convex, the punctures close, deep, rather coarse, confused. Declivital interspaces (Figs. 8, 9) convex, three slightly higher; one, three, five, seven, and nine usually finely serrate, but serrations entirely absent in some specimens, usually coarser on three; interspaces two and three subequal in width, one narrower; on left elytron two occasionally narrower than one and flat. Vestiture consisting of small, abundant, erect interstrial scales, each scale slightly longer than wide.

Male.—Similar to female except: frons coarsely punctured, tranversely impressed (longitudinally concave), with the median, bituberculate, transverse elevation characteristic of genus; vestiture evidently somewhat more abundant and scales slightly wider.

Type Locality.—Camp Baldy, San Bernardino County, California.

Host.—*Pseudotsuga macrocarpa*.

Distribution.—Southern California; evidently limited to the range of the host tree. Specimens from the following California localities were examined: Los Angeles County (Arroyo Seco, Mount Wilson and Pasadena), San Bernardino County (Camp Baldy), Ventura County (Santa Paula).

The above description of the female was prepared from the allotype, except measurements (which are composite) and obvious departures where "usually"

or "variable" is used. The holotype was one of the speciments used in determining the male characters. In addition to these specimens, two paratypes, and 106 other specimens (two of them paratypes of *cressatyi*) were studied before preparation of the description. The type of *blaisdelli* is in the Canadian National Collection; that of *cressatyi* (described from *Pseudotsuga macrocarpa* at Arroyo Seco in Los Angeles County, California) is in the collection of Ohio State University. Bruck erroneously recognized the common species *pinicolens* as *blaisdelli*, and as a result renamed this comparatively rare species *cressatyi*.

Carphoborus vandykei Bruck

Figs. 1, 2, 3, 10, 11

Carphoborus vandykei Bruck, 1933, Can. Ent. 65: 104; Bruck, 1936, Bull. Southern California Acad. Sci. 35: 114; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 130.

This species is closely allied to, and somewhat intermediate between, *blaisdelli* and *pinicolens*. From the former species it is distinguished by the second declivital interspace being much narrower than the third and flat, and the third interspace usually more strongly elevated. From *pinicolens* it is distinguished only with difficulty when individuals are examined; series have a more distinctly brown (often reddish) colour, less strongly elevated third and ninth declivital interspaces, smaller and less numerous declivital teeth, and *more strongly arched sutures* of the antennal club (compare Figs. 3 and 5).

Female.—Length 1.8-2.6 mm., 2.3 times as long as wide; colour almost black, but always with a brownish cast, particularly on posterior half.

Frons flattened, with epistomal region marginally elevated and medially produced (variable) in front of mandibles; surface reticulate, impunctate on a subcircular median area the diameter of which equals about one-third the distance between the eyes, punctures deep and close surrounding this area; pubescence arising from punctured and epistomal areas fine, rather long. Antennal club 1.17 times as long as wide; sutures suboblique, arcuate (Fig. 3).

Pronotum 1.2 times as wide as long; sides almost straight on basal half, slightly converging anteriorly, laterally constricted just behind the very broadly rounded anterior margin; surface finely, indistinctly reticulate, punctures of moderate size, rather close, deep; median line usually distinct on middle third; vestiture consisting of abundant small, erect scales, each scale distinctly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind, basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspaces (Figs. 10, 11) one and two subequal in width and narrower than three; one and three distinctly elevated; two flat (rarely slightly concave or convex); one, three, five, seven, and nine finely serrate, rarely the teeth entirely absent. Vestiture consisting of small, abundant, erect, interstrial scales, each scale indistinctly longer than wide.

Male.—Similar to female except: frons coarsely punctured, transversely impressed (longitudinally concave), with the median, bituberculate, transverse, elevation characteristic of genus; vestiture evidently somewhat more abundant and scales wider.

Type Locality.—Mount St. Helena, California.

Host.—*Pseudotsuga taxifolia*.

Distribution.—Central California to southern British Columbia. Specimens from the following localities were examined. *British Columbia*: Pender Harbor.

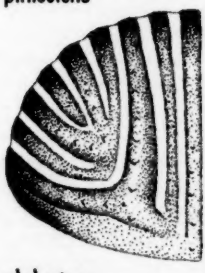
8. blaisdelli

10. vandykei

12. pinicolens

9. blaisdelli

11. vandykei

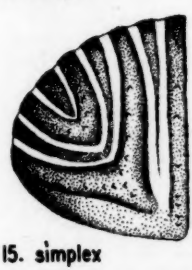


13. pinicolens

14. simplex

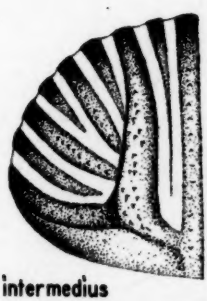
16. convexifrons

18. pseudotsugae



15. simplex

17. declivis



19. intermedius

Figs. 8-19.—*Carphoborus* spp., declivity of left elytron: 8, dorsal, and 9, caudal aspect of *blaisedelli*; 10, dorsal, and 11, caudal aspect of *vandykei*; 12, dorsal, and 13, caudal aspect of *pinicolens;* 14, dorsal, and 15, caudal aspect of *simplex;* 16, caudal aspect of *convexifrons*; 17, caudal aspect of *declivis*; 18, caudal aspect of *pseudotsugae*; and 19, caudal aspect of *intermedius*

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California: Del Norte County, French Hill, Mount St. Helena, Quincy, and Yosemite National Park. *Oregon:* Ashland, Oregon Caves, St. Helens, and Waldo.

The above description was prepared from the female paratype in the Canadian National Collection, except measurements and the statements that indicate obvious departures therefrom. Three additional paratypes and 219 other specimens were studied before preparation of the description. The type specimen of *vandykei* is in the collection of Ohio State University.

Carphoborus pinicolens, new species

Figs. 5, 12, 13

Carphoborus blaisdelli, Bruck, 1936, Bull. Southern California Acad. Sci. 35: 116.
Carphoborus simplex, Bruck, 1936, Bull. Southern California Acad. Sci. 35: 113.

This species is very closely related to *vandykei*, and less closely allied to the four following species. From *vandykei* it is distinguished with difficulty by the black colour, the more strongly elevated third and ninth declivital interspaces, the larger and more numerous declivital teeth, and the less strongly arched sutures of the antennal club; the characters of the antennal club provide the most reliable and useful means of separating these species. From *simplex* it is readily separated by the broad antennal club, the less strongly elevated third and ninth declivital interspaces, and the narrow second declivital interspaces, which continue to the apex. From *brevisetosus*, *frontalis*, and *convexifrons* it is distinguished by the flattened frons and the longer, incurved frontal hair of the female.

Female.—Length 2.4 mm. (paratypes 1.7-2.5 mm.), 2.3 times as long as wide; colour black.

Frons flattened, with epistomal region transversely elevated, and epistomal margin medially produced in front of mandibles (variable in a series); surface reticulate, impunctate on a subcircular median area the diameter of which equals about one-fourth the distance between the eyes; the punctures surrounding this area deep, close, coarser than in allied species; pubescence arising from punctured and epistomal areas fine, rather long, incurved. Antennal club about as long as wide; sutures transverse, the first straight, others slightly arcuate (Fig. 5).

Pronotum 1.2 times as wide as long; sides almost straight on basal half, converging slightly anteriorly, laterally constricted just in front of the very broadly rounded anterior margin; surface reticulate; punctures rather coarse and close, deep; median line usually elevated and impunctate; vestiture consisting of abundant small, erect scales; each scale distinctly longer than wide, somewhat more slender toward median and anterior areas in some specimens.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspaces (Figs. 12, 13) one and two subequal in width and distinctly narrower than three; one and three distinctly elevated; two flat; one, three, five, seven, and nine serrate. Vestiture consisting of small, abundant, erect, interstrial scales, each scale distinctly longer than wide.

Male.—Similar to female except: frons tranversely impressed (longitudinally concave), coarsely punctured, with the median, bituberculate, transverse elevation characteristic of the genus above the impression; vestiture evidently somewhat more abundant and scales slightly wider.

Type Locality.—Logan Dry Canyon, Utah.

Hosts.—Pinus edulis, P. flexilis, P. lambertiana, P. leiophylla, P. monophylla (type), and *P. ponderosa.*

Distribution.—Colorado and New Mexico to the Pacific coast. The holotype, allotype, and 173 paratypes were collected at the type locality on July 1, 1947, from *Pinus monophylla* by the author. Several hundred additional specimens, not designated as paratypes, were examined from the following localities. *Arizona:* Chiricahua National Monument, Flagstaff, Santa Catalina Mountains, and Williams. *California:* Anderson Valley (Stanislaus National Forest, Mariposa County), General Grant National Park, Glenn County, Lava Ranger Station, Mount Hawkins, San Francisco, and Ventura. *Colorado:* Mancos, Mesa Verde National Park, Salida, Ute Pass, and Woodland Park. *Nevada:* Baker. *New Mexico:* Capitan, Cloudcroft, Las Vegas, and Manzano. *Oregon:* Ashland, Grants Pass, Pinehurst, and Portland. *Utah:* Bryce Canyon National Park. Logan Canyon, Panguitch, and Zion National Park. *Wyoming:* Saratoga.

The holotype, allotype, and several paratypes are in the U.S. National Museum; the other paratypes are in the Canadian National Collection and in the collections of the California Academy of Sciences, Cornell University, and Ohio State University.

This species appears to be the most widely distributed and abundant representative of the genus in North America. This evidently influenced Bruck (1933) and led him to assume that it was *simplex;* as a result he renamed the true *simplex* as a new species (*swainei*). Bruck evidently did not see specimens of the true *blaisdelli*, but used the original description, and possibly personal communications from Swaine and others, to diagnose his species. He placed *blaisdelli* in his key as would be done if the original description were followed; however, he recorded pine, not *Pseudotsuga macrocarpa*, as the host. Either he guessed that the host was pine, or the specimens at hand represented Leconte's *simplex* or the species described above as *pinicolens*. If he did not guess, and if it is assumed that he recognized *simplex* Leconte (which he called *swainei*), the specimens in question must have been of *pinicolens*. Another species occurring in pine in southern California is *frontalis;* however, specimens of this species did not become available to Bruck until after 1936.

Carphoborus simplex Leconte

Figs. 14, 15

Carphoborus simplex Leconte, 1876, Proc. Amer. Philos. Soc. 15: 383; Swaine, 1918, Canada Dept. Agr. Ent. Br. Bull. 14(2): 56; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 129.

Carphoborus swainei Bruck (new synonymy), 1933, Can. Ent. 65: 105; Bruck, 1936, Bull. Southern California Acad. Sci. 35: 117; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 130.

This species is rather closely allied to *vandykei* and *pinicolens*, but is readily distinguished by the more strongly elevated first, third and ninth declivital interspaces, the much narrower second declivital interspaces which are usually eliminated on the upper half by convergence of striae one and two, and the more slender antennal club.

Female.—Length 1.8-2.4 mm., 2.3 times as long as wide.

Frons flattened, with epistomal region transversely elevated; epistomal margin usually without median area produced; surface reticulate, impunctate on a subcircular median area the diameter of which equals about one-third the distance between eyes, punctures surrounding this area rather fine, shallow; pubescence arising from the punctured area rather fine, moderately long. Antennal club 1.2 times as long as wide, the sutures slightly arcuate.

Pronotum 1.2 times as wide as long; sides almost straight on basal half, converging slightly anteriorly, laterally constricted just behind the broadly rounded anterior margin; surface reticulate, punctures of moderate size, not close; median line elevated and moderately distinct on middle third; vestiture consisting of abundant small, erect scales, each scale slightly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspace (Figs. 14, 15) two made obsolete on upper half by convergence of striae one and two; one, three, and nine moderately elevated and serrate; five and seven also with a few teeth near apex. Vestiture consisting of small, abundant, interstrial scales; each scale about as long as wide.

Male.—Similar to female except: frons transversely impressed (longitudinally concave), more coarsely punctured (less strongly impressed and more finely punctured than in males of *pinicolens*), the median bituberculate, transverse elevation above the impression present as in most other species of genus; body vestiture evidently somewhat more abundant and scales wider.

Type Locality.—Mojave Desert, California.

Hosts.—*Pinus lambertiana* and *P. sabiniana.*

Distribution.—California and Baja California. Specimens from the following localities were examined. *Baja California:* San Isidor. *California:* Anderson Valley (Stanislaus National Forest, Mariposa County), Chiquite Basin (Madera County), Cleveland National Forest, Hollister, Idyllwild, Los Angeles County, Mount Diablo, North Fork, Placerville, Red Bluff, Redding, and Ventura County.

Before preparation of the above description, Leconte's type was examined (comparisons with other species were also made by Mr. W. J. Brown) and 229 other specimens were studied, four of which were paratypes of *swainei.* The type of *simplex* is in the Museum of Comparative Zoology, Harvard College, that of *swainei* (described from *Pinus sabiniana*, Mount Diablo, California) is in the collection of Ohio State University.

Carphoborus brevisetosus, new species

This species is very closely allied to *pinicolens* but differs by having the frons more strongly convex, the frontal vestiture much shorter (about one-half as long), and the punctures of the frons and the pronotum finer.

Female.—Length 2.4 mm. (paratypes 2.0-2.4 mm.), 2.3 times as long as wide.

Frons weakly convex, transversely impressed just above the distinctly elevated epistomal margin; epistomal margin medially produced (variable in a series) in front of mandibles; surface indistinctly reticulate, impunctate on a subcircular median area the diameter of which equals about one-third the distance between eyes; punctures surrounding this area rather fine, shallow; pubescence arising from punctured area rather fine, short. Antennal club 1.2 times as long as wide; sutures transverse, almost straight.

Pronotum 1.2 times as wide as long; sides straight on basal half, converging slightly anteriorly, laterally constricted just behind the very broadly rounded anterior margin; surface reticulate, punctures of moderate size, rather close, and deep; median line usually distinct on middle third; vestiture consisting of abundant small, erect scales, each scale slightly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind, basal margin elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large.

deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, rather fine. Declivity as in *pinicolens;* interspaces one and two subequal in width and distinctly narrower than three; one slightly, three distinctly elevated; three and nine finely serrate; one, five, and seven usually with a few teeth near apex. Vestiture consisting of small, abundant, erect, interstrial scales; each scale indistinctly longer than wide.

Male.—Unknown.

Type Locality.—Saratoga, Wyoming.

Host.—Picea pungens.

Type Material.—The female holotype and two paratypes were collected at the type locality on July 28 (lot 955-2) from *Picea pungens* by D. DeLeon, and three paratypes on July 17 (Hopk. U.S. 31529e) from the same host and locality. The holotype and two paratypes are in the collection of the U.S. National Museum; the other three paratypes are in the Canadian National Collection.

***Carphoborus frontalis*, new species**

This species is closely allied to *pinicolens*, *brevisetosus*, and *convexifrons* but differs by having a broad, raised, median line on the lower half of the frons (both sexes), and by the predominantly hairlike pubescence on the pronotal disc. The female is also distinguished from the female of *pinicolens* by having a weakly convex frons with a larger median impunctate area; from *brevisetosus* by having longer frontal pubescence and a larger impunctate frontal area in the female, and by having a more coarsely punctured pronotum and more coarsely sculptured elytral declivity in both sexes; and from *convexifrons* by having a less strongly convex frons and longer frontal pubescence in the female, and by having a less coarsely punctured pronotum and the second declivital interspaces continuing to apex in both sexes.

Female.—Length 2.5 mm. (paratypes 1.8-2.5 mm.), 2.6 times as long as wide.

Frons weakly convex, the median line broadly, indistinctly raised from upper level of eyes to epistoma, transversely impressed above epistoma; epistomal area with median area produced in front of mandibles; surface finely reticulate, impunctate on subcircular median area the diameter of which equals about one-half the distance between the eyes, punctures surrounding this area rather fine, shallow; pubescence arising from punctured area rather coarse, moderately long. Antennal club about as long as wide, the sutures weakly arcuate.

Pronotum 1.2 times as wide as long; sides converging slightly anteriorly, a distinct lateral constriction one-third the distance from base, and another just behind the broadly rounded anterior margin; surface reticulate, punctures moderately coarse and close; median line usually elevated and impunctate; vestiture consisting of abundant small, erect, almost hairlike (often bifid) scales; a few shorter, stout scales intermixed in lateral areas.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivity similar to that of *pinicolens;* interspaces one and three moderately elevated; one, three, five, seven, and nine rather coarsely serrate at least near apex; interspace two depressed, as narrow as one, narrower than three, continuing to apex. Vestiture consisting of abundant scales; each scale longer than wide, some of those on first and second declivital interspaces longer and hairlike.

Male.—Similar to the female except: frons transversely impressed on lower

half (longitudinally concave), with the median, bituberculate, transverse elevation at upper level of impression characteristic of the genus; the frontal impression with a broad, weak, median elevation; impunctate area of frons smaller, punctures coarser, and pubescence shorter.

Type Locality.—Ventura County, California.

Hosts.—*Pinus edulis* (type) and *P. monophylla*.

Type Material.—The female holotype, male allotype, and 16 paratypes were collected at the type locality on April 6, 1906 (lot 2781a), from *Pinus edulis* by A. D. Hopkins. Seventy-seven other paratypes were collected in California as follows: Frazier Mountain, Sept. 6, 1940; Valyermo, Jan. 17, 1936, and Jan. 26, 1937, by A. T. McClay; and Ventura County, Jan. 17, 1905 (lot 277g), by A. D. Hopkins.

The holotype, allotype, and several paratypes are in the collection of the U.S. National Museum; additional paratypes are in the Canadian National Collection and collections of the California Academy of Sciences and Ohio State University.

Carphoborus convexifrons, new species

Fig. 16

This species is closely allied to *frontalis* but is readily separated by the rather strongly convex frons and very short (subglabrous) frontal pubescence of the female, the more coarsely punctured pronotum, the scalelike vestiture on the pronotal disc, and the second interspaces made extremely narrow or obsolete on the upper half of the declivity by convergence of striae one and two (usually narrower than illustrated in Fig. 16).

Female.—Length 2.5 mm. (paratypes 1.8-2.5 mm.), 2.3 times as long as wide.

Frons broadly, rather strongly convex, transversely impressed above epistoma; epistomal margin medially produced (variable in a series) in front of mandibles; surface indistinctly reticulate, impunctate on a subcircular area the diameter of which equals about one-half the distance between eyes, the punctures rather fine and shallow surrounding this area; pubescence arising from punctured area very short and inconspicuous except on epistomal margin (the epistomal brush), where setae are of normal length and about four times longer than on sides and above. Antennal club about as long as wide, the sutures arcuate.

Pronotum 1.2 times as wide as long; sides converging slightly anteriorly, with a distinct lateral constriction one-third the distance from base and another just behind the broaded rounded anterior marking; surface reticulate, punctures very coarse and close; median line raised near centre, largely obliterated by punctures; vestiture consisting of abundant small, erect scales, each scale indistinctly longer than wide.

Elytra 1.8 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, coarse. Declivital interspaces (Fig. 16) one and three moderately elevated, two depressed and made obsolete (or at least very narrow) on upper half by convergence of striae one and two; interspaces one, three, five, seven, and nine serrate at least near apex. Vestiture consisting of abundant scales, each scale indistinctly longer than wide.

Male.—Similar to the female except: frons transversely impressed on lower half (longitudinally concave), with the median, bituberculate, transverse elevation above the impression characteristic of the genus; surface of frons more coarsely

punctured, the pubescence more than twice as long, and the impunctate area much smaller.

Type Locality.—Chiricahua National Monument, Arizona.

Hosts.—*Pinus edulis* and *P. leiophylla* (type).

Type Material.—The female holotype, male allotype, and nine paratypes were collected at the type locality on Oct. 1, 1936 (lot 838-2), from *Pinus leiophylla* by D. DeLeon. Nine other paratypes were collected as follows: Santa Catalina Mountains, Arizona (lots 7703 and 7705), by M. Chrisman; and Peloncillo National Forest, New Mexico, Nov. 12, 1907 (bred Jan. 6, 1908) (Hopk. U.S. 5593), by J. L. Webb.

The holotype, allotype, and several paratypes are in the U.S. National Museum; additional paratypes are in the Canadian National Collection and collections of the California Academy of Sciences.

Carphoborus sansoni Swaine

Figs. 26, 27

Carphoborus sansoni Swaine, 1924, Can. Ent. 56: 235; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 132.

Carphoborus engelmanni Wood (new synonymy), 1951, J. Ent. Soc. Kansas 24: 31.

This species is very closely allied to *andersoni;* it differs by the more strongly elevated and serrate first declivital interspaces, and less strongly elevated third declivital interspaces. Possibly the two forms are only subspecifically distinct.

Female.—Length 1.8-2.1 mm., 2.4 times as long as wide.

Frons flattened, weakly impressed above the elevated epistoma; epistomal margin medially produced in front of mandibles; surface rather coarsely punctured; vestiture rather long, coarse. Antennal club 1.3 times as long as wide, the sutures straight.

Pronotum 1.2 times as wide as long; sides slightly arcuate, indistinctly converging anteriorly, a weak lateral constriction just behind the broadly rounded anterior margin; surface reticulate, punctures of moderate size, deep, close; median line elevated only near middle; vestiture consisting of abundant small, erect scales, each scale distinctly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind, the posterior profile interrupted by the elevated declivital interspaces; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspaces one and three moderately elevated; one highest just above apex; three highest near middle of declivity (Figs. 26, 27); interspace two very slender, flat; interspaces one, three, five, and seven serrate; nine usually with one or two teeth at or anterior to declivital base (not serrate as originally described by Swaine); declivital elevation ending at junction of interspaces three and nine, not continued across interspace two. Vestiture consisting of large, abundant, erect, interstrial scales, each scale longer than wide.

Male.—Similar to female except: frons convex above, strongly, transversely impressed below (longitudinally concave), the median bituberculate, transverse elevation as in other species of the genus; surface of frons more coarsely, deeply punctured, and vestiture shorter.

Type Locality.—Banff, Alberta.

Hosts.—*Picea engelmannii* and *P. glauca*.

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Distribution.—Alberta to Utah. Specimens from the following localities were examined. *Alberta:* Banff. *Utah:* Beaver, Logan Canyon, and Monte Cristo. *Wyoming:* Yellowstone National Park.

Fifty-three specimens were studied before preparation of the above description. The description of the female is based on the type of *engelmanni*, that of the male on the type of *sansoni*. The type of *sansoni* is in the Canadian National Collection; that of *engelmanni* (described from *Pisea engelmannii*, Logan Dry Canyon, Utah) is in the U.S. National Museum.

The ninth declivital interspace was originally described by Swaine as being serrate, and the species was compared to *carri*. This combination of factors led me to describe specimens collected in Utah as a distinct species; actually the Utah specimens are indistinguishable from Swaine's type.

Carphoborus andersoni Swaine

Figs. 28, 29

Carphoborus andersoni Swaine, 1919, Rept. Canadian Arctic Exped. 3: 6E; Bruck, 1936, Bull. Southern California Acad. Sci. 35: 115; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 130.

This species is very closely allied to *sansoni;* possibly it is only a northern subspecies. It is distinguished by the less strongly elevated, more finely serrate first declivital interspaces, and more strongly elevated third declivital interspaces (particularly at apical end of elevation).

Female.—The description of this species is exactly the same as that of *sansoni* except for the elytral declivity; for this reason only the posterior area of the type is described.

Declivital interspace one slightly elevated, finely serrate (Figs. 28, 29); interspace two very narrow, impressed; interspace three strongly, narrowly elevated, highest near apical end of elevation, teeth rather long and slender; interspaces five and seven serrate; nine almost flat, with one or two teeth at, or anterior to, declivital base.

Type Locality.—Sandstone Rapids, Coppermine River, Northwest Territories.

Host.—Picea glauca.

Distribution.—Northwest Territories to Alaska. Five female specimens were examined: three are from the type locality; two are from Fort Yukon, Salmon River, Alaska.

The type specimen is in the Canadian National Collection.

Carphoborus dunni Swaine

Figs. 30, 31

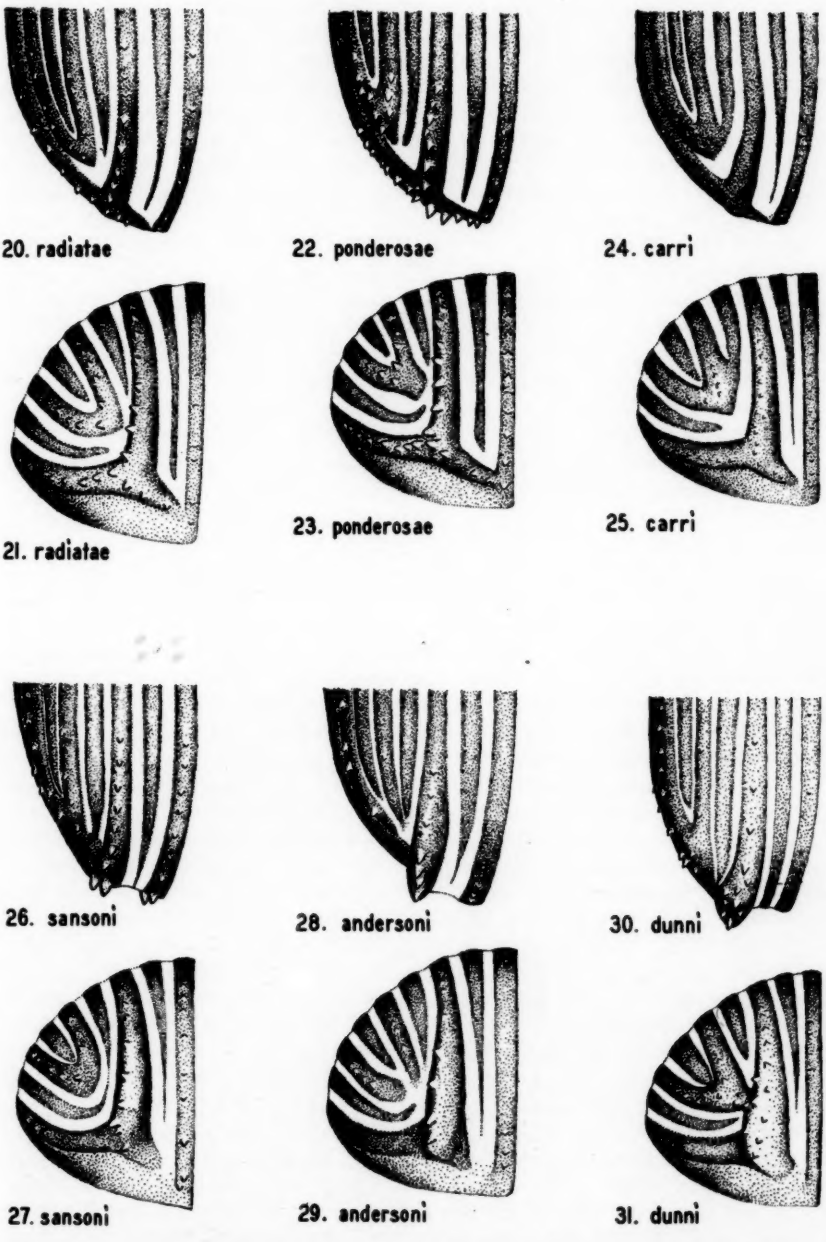
Carphoborus dunni Swaine, 1924, Can. Ent. 56: 235; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 132.

This species is allied to *andersoni* and *sansoni* but differs by the granulate surface and shorter pubescence of the female frons, by the higher, wider elevation of the third declivital interspaces, and by the serrations on the third declivital interspaces, which are small, confused, more abundant on the sides of the elevation than on its summit.

Female.—Length 1.6-1.9 mm., 2.4 times as long as wide.

Frons convex, transversely impressed above the slightly elevated epistoma; epistomal margin medially produced in front of mandibles; surface granulate-punctate; vestiture very short, scanty. Antennal club 1.4 times as long as wide, the sutures straight.

Pronotum 1.2 times as wide as long; sides convergently arcuate anteriorly, laterally constricted just behind the broadly rounded anterior margin; surface reticulate, the punctures deep, rather close, of moderate size; vestiture consisting of abundant small, semi-erect, very slender scales (almost hairlike).



Figs. 20-31.—*Carphoborus* spp., declivity of left elytron; 20, dorsal and 21, caudal aspect of *radiatae*; 22, dorsal, and 23, caudal aspect of *ponderosae*; 24, dorsal, and 25, caudal aspect of *carri*; 26, dorsal and 27, caudal aspect of *sansoni*; 28, dorsal, and 29, caudal aspect of *andersoni*; 30, dorsal, and 31, caudal aspect of *dunni*.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, narrowly subtruncate behind, the posterior profile interrupted by the elevated third interspaces; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspace (Figs. 30, 31) one weakly elevated, finely serrate; two very narrow, flat; three very strongly, rather broadly elevated, with the teeth confused, not confined to summit; five and seven serrate, slightly elevated, joining apically and this elevation usually continuing to interspace three; nine usually entirely devoid of teeth behind declivital base, weakly or not at all convex. Vesiture consisting of rather large, slender, abundant, semi-erect, interstrial scales.

Male.—Similar to female except: frons more strongly convex, the impression deeper, a median transverse elevation indicated; surface of frons more coarsely punctured.

Type Locality.—Nictor Lake, New Brunswick.

Host.—Picea rubens.

Distribution.—Known only from the type series of five specimens.

The above descriptions were prepared from the female holotype and male allotype, which are in the Canadian National Collection.

***Carphoborus radiatae* Swaine**

Figs. 20, 21

Carphoborus radiatae Swaine, 1918, Canada Dept. Agr. Ent. Br. Bull. 14(2): 57; Bruck, 1936, Bull. Southern California Acad. Sci. 35: 112; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 129.

This species is allied to *ponderosae* but is readily distinguished by the concave frons of the female, the more strongly impressed frons of the male, and the much coarser frontal punctures and less strongly elevated, more finely, sparsely serrate third and ninth declivital interspaces of both sexes.

Female.—Length 1.8-2.4 mm., 2.4 times as long as wide.

Frons broadly, shallowly concave on an area the diameter of which equals about three-fourths of the distance between the eyes, and extending from just above epistoma to well above the upper level of the eyes; epistomal area elevated and medially produced (variable in a series) in front of mandibles, entire surface very coarsely punctured (finer below) and pubescent; vestiture rather long and moderately fine. Antennal club 1.5 times as long as wide, the sutures straight.

Pronotum 1.2 times as wide as long; sides almost straight on basal half, converging slightly anteriorly, indistinctly constricted just behind the very broadly rounded anterior margin; surface reticulate, punctures coarse, deep, close; median line elevated and distinct on middle half; vestiture consisting of abundant small, erect scales, each scale distincly longer than wide.

Elytra 1.8 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind, basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspace (Figs. 20, 21) one wider than two, but distinctly narrower than three; one slightly, three and nine distinctly elevated, two flat; one, three, five, seven, and nine sparsely serrate at least apically. Vestiture consisting of small, abundant, semi-erect, interstrial scales, each scale distinctly longer than wide.

Male.—Similar to the female except: frons rather strongly, transversely

impressed (longitudinally concave) below the median bituberculate, transverse elevation; surface of frons coarsely, deeply punctured, vestiture shorter.

Type Locality.—Carmel, Monterey County, California.

Host.—Pinus radiata.

Distribution.—Known only from the type locality. Twenty-five specimens representing five series, collected between 1913 and 1919, were examined.

The above description of the female was based on the type, which is in the Canadian National Collection. In Swaine's original description the sexes were reversed; consequently, the type is a female, not a male.

***Carphoborus ponderosae* Swaine**

Figs. 4, 22, 23

Carphoborus ponderosae Swaine, 1924, Can. Ent. 56: 236; Bruck, 1936, Bull. Southern California Acad. Sci. 35: 118; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 131.

This species is allied to *radiatae* but is distinguished by the flattened, less coarsely punctured frons of the female, by the less strongly impressed frons of the male, and by the less strongly elevated, more coarsely, closely serrate third and ninth declivital interspaces of both sexes.

Female.—Length 1.8-2.1 mm., 2.3 times as long as wide.

Frons flattened, epistomal region moderately elevated; epistomal margin medially produced (variable in a series) in front of mandibles; surface shining, rather coarsely punctured over entire frontal area, punctures rather deep, moderately close; vestiture rather long, fine. Antennal club (Fig. 4) small, 1.5 times as long as wide, the sutures straight.

Pronotum 1.3 times as wide as long; sides arcuately converging anteriorly, laterally constricted just behind the broadly rounded anterior margin; surface reticulate, the punctures moderately coarse and close, rather deep; median line slightly elevated, impunctate; vestiture consisting of abundant small, erect scales, each scale slightly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind, basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspaces (Figs. 22, 23) one moderately, three and nine rather strongly elevated; two flat; one, three, five, seven, and nine very coarsely serrate; the elevation continuing from junction of three and nine to one, usually serrate. Vestiture consisting of small, abundant, erect, interstrial scales, each scale about as long as wide.

Male.—Similar to female except: frons moderately, transversely impressed below (longitudinally concave), the median elevation above the impression usually absent; surface of frons more coarsely punctured, vestiture shorter; pronotal scales stouter, at least as wide as long.

Type Locality.—Midday Valley, Merritt, British Columbia.

Hosts.—Pinus contorta and *P. ponderosa* (type).

Distribution.—British Columbia to Utah. Specimens from the following localities were examined. *British Columbia:* Midday Valley near Merritt. *Montana:* Bozeman and Clinton. *Oregon:* Fort Rock. *Utah*: La Sal Mountains and Logan Canyon.

The above descriptions were based on the female holotype and male allotype, which are in the Canadian National Collection. One hundred and sixty-two other specimens of this species were also studied.

Carphoborus declivis, new species

Fig. 17

This species is not closely related to any known North American species, but is perhaps more closely allied to *pseudotsugae* than to other species of the genus. It differs from all others by the presence of small teeth on the comparatively broad second declivital interspaces. It resembles *pseudotsugae* in having declivital interspaces four, six, and eight serrate.

Female.—Length 2.0 mm. (paratypes 1.7-2.0 mm.), 2.3 times as long as wide.

Frons planoconvex, finely, densely granulate; epistomal margin raised and medially produced in front of mandibles (variable in a series); vestiture of moderate length, fine. Antennal club 1.4 times as long as wide; the sutures straight.

Pronotum 1.2 times as wide as long; sides arcuately converging anteriorly, indistinctly constricted just behind the broadly rounded anterior margin; surface subreticulate, punctures of moderate size, deep, close; median line not evident; vestiture consisting of abundant small, erect scales, each scale distinctly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, coarse. Declivital interspaces (Fig. 17) one and two of equal width, three wider; all interspaces convex, with one, five, seven, and nine slightly, three moderately elevated; all declivital interspaces serrate, finer on two and six, rather coarse on three. Vestiture consisting of small, abundant, semi-erect, interstrial scales, each scale about as long as wide.

Male.—Similar to female except: frons with moderate, transverse impression (longitudinally concave) below the rather low, median, bituberculate, transverse elevation; surface of frons very coarsely punctured, the vestiture shorter, rather coarse; scales on pronotum wider.

Type Locality.—Lake Tenaya, Yosemite National Park, California.

Host.—*Pinus contorta* (type series labeled *murrayana*).

Type Material.—The female holotype, male allotype, and four paratypes were collected on Aug. 11, 1918 (Hopk. U.S. 15740a and b), from *Pinus contorta* by J. E. Patterson.

The holotype, allotype, and one paratype are in the U.S. National Museum, and three paratypes are in the Canadian National Collection.

Carphoborus pseudotsugae, new species

Fig. 18

This species is allied to *declivis* and *intermedius* but is distinguished by the rather strongly protruding frons of the female; from the former species it is also separated by the very narrow, non-tuberculate second declivital interspaces; from the latter species it also differs by the presence of serrations on interspaces four, six, and eight, the much less strongly elevated third declivital interspaces, and the granulate frons of the female.

Male.—Length 2.1 mm., 2.3 times as long as wide.

Frons moderately, transversely impressed, longitudinally concave below the median transverse elevation; epistomal margin elevated, produced medially in front of mandibles; surface coarsely, rather deeply punctured; vestiture rather short, coarse. Antennal club 1.3 times as long as wide, the sutures very slightly arcuate.

Pronotum 1.3 times as wide as long; sides straight and subparallel on basal half, abruptly converging anteriorly to the broadly rounder anterior margin; surface shining, subreticulate, punctures rather coarse, deep, close; median line evident only near centre; vestiture consisting of abundant small, erect scales, each scale indistinctly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, rather broadly rounded behind, basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, deep, rather coarse. Declivital interspace (Fig. 18) two very narrow, almost obsolete; one narrower than three; one and nine slightly, three moderately elevated; one and three to nine serrate, the teeth on three larger and more numerous. Vestiture consisting of small, abundant, semi-erect, interspacial scales, each scale about as long as wide.

Female.—Similar to the male except: frons more strongly convex above; the transverse impression above epistoma more abrupt, narrower (longitudinally); frons more finely granulate-punctate than in male, but much coarser than in females of other North American species. Vestiture on frons largely abraded, evidently rather short and fine; more slender on pronotum than in male.

Type Locality.—Prescott National Forest, Arizona.

Host.—Pseudotsuga taxifolia.

Type Material.—The male holotype and female allotype were collected at the type locality on July 29, 1930 (Hopk. U.S. 20412E), from *Pseudotsuga taxifolia* by M. W. Blackman. The pronotum of the allotype is badly crushed.

The holotype and allotype are in the U.S. National Museum.

Carphoborus intermedius, new species

Fig. 19

This species is rather closely allied to *carri* but is readily distinguished by the subtuberculate fourth and eighth declivital interspaces, by the more strongly elevated third declivital interspaces, by the narrower discal striae, and by the larger average size. It may be separated from *pseudotsugae* by the absence of distinct teeth on declivital interspaces four, six, and eight, the more strongly elevated third declivital interspace, and the shining, punctured, flat female frons.

Male.—Length 2.1 mm. (paratypes 1.9-2.1 mm.), 2.3 times as long as wide.

Frons convex above, transversely impressed below, the median elevation absent; epistoma slightly elevated, the margin medially produced in front of mandibles (variable in a series); surface coarsely, shallowly, not closely punctured; vestiture very short, coarse. Antennal club 1.3 times as long as wide, the sutures straight.

Pronotum 1.3 times as wide as long; sides arcuately converging anteriorly, laterally constricted just behind the broadly rounded anterior margin; surface subtuberculate, punctures rather coarse, deep, very close; median line evident only near centre; vestiture consisting of abundant small, erect scales, each scale indistinctly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, appearing narrowly truncate behind, the posterior profile interrupted by the elevated declivital interspaces; basal margins elevated and armed with about ten large, overlapping crenulations; striae slightly impressed, the punctures rather large, deep, close; interstriae about as wide as striae, weakly convex, the punctures confused, close, rather deep and coarse. Declivital interspace (Fig. 19) two very narrow, almost obsolete; three wider than one; one and nine moderately, three strongly elevated; one, three, five, seven, and nine rather finely serrate, four

and eight subtuberculate behind (these form definite teeth in one paratype); five and seven ending separately on right elytron of type, fusing on the left side (evidently this is a variable character in this species). Vestiture consisting of abundant semi-erect, interstrial scales, each scale about as long as wide.

Female.—Similar to male except: frons flat, shining, rather coarsely punctured; epistoma gradually raised toward margin; vestiture of frons very long, fine, less abundant and shorter near centre.

Type Locality.—New Castle, Colorado.

Hosts.—*Picea engelmannii* (type) and *Pinus contorta.*

Type Material.—The male holotype was collected at the type locality (Hopk. U.S. 31408-2-4) from *Picea engelmannii* by C. L. Massey; the female allotype was collected at Grand Lake, Colorado, on Oct. 5, 1938 (Hopk. U.S. 31542-J2), from *Pinus contorta;* two male paratypes are labelled "Metaline Falls, Washington, July 15, 1932 (Hopk. U.S. 22366), T. T. Terrell collector, flight"; and fourteen paratypes were taken at Tollgate, Oregon, July 1-15, 1950, on an aluminum roof by E. S. McClusky. The posteroventral half of the head is missing from the allotype.

The holotype and allotype are in the U.S. National Museum; the paratypes are in the Canadian National Collection.

Carphoborus carri Swaine

Figs. 24, 25

Carphoborus carri Swaine, 1917, Canada Dept. Agr. Ent. Br. Bull. 14(1): 16; Swaine, 1918, Canada Dept. Agr. Ent. Br. Bull. 14(2): 57; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 131.

This species is allied to *intermedius* and *bifurcus* but is distinguished by the less strongly elevated third declivital interspaces. From *intermedius* it is also separated by the small average size, narrower discal interspaces, and much larger elytral scales. From *bifurcus* it also differs by the flat, shining, punctured female frons; by interspaces five and seven converging and joining posteriorly; and by the elevation between the junction of interspaces three and nine and interspace one not well developed or serrate.

Female.—Length 1.4-2.0 mm., 2.3 times as long as wide.

Frons flattened; epistomal region slightly elevated, medially produced in front of mandibles, transversely impressed above epistoma; surface shining, closely, deeply rather finely punctured; vestiture long, fine. Antennal club 1.3 times as long as wide; the sutures straight.

Pronotum 1.3 times as wide as long; sides arcuately converging anteriorly, laterally constricted just behind the broadly rounded anterior margin; surface reticulate, closely, rather coarsely punctured; median line evident near middle; vestiture consisting of abundant small, erect scales, each scale indistinctly longer than wide.

Elytra 1.7 times as long as wide; sides subparallel on basal two-thirds, appearing rather narrowly truncate behind, the posterior profile interrupted by the elevated declivital interspaces; striae slightly impressed, the punctures very large, close, deep; interstriae much narrower than striae, convex, the punctures confused, close, deep, coarse. Declivital interspaces (Figs. 24, 25) one and two rather narrow, three wider; one and nine slightly, three moderately elevated, the elevation continuing from junction of three and nine to one rather poorly developed, often incomplete; one, three, five, seven, and nine finely serrate. Vestiture consisting of rather large, abundant, semi-erect, interspacial scales, each scale about as long as wide and many of them appearing multilamellate.

Male.—Similar to female except: transverse frontal impression deeper, wider (longitudinally), median area not elevated above impression; surface of frons coarsely punctured, the vestiture short and rather coarse.

Type Locality.—Edmonton, Alberta.

Hosts.—Picea glauca and *P. rubens.*

Distribution.—Alberta to New Brunswick, and South Dakota. Specimens from the following localities were examined. *Alberta:* Banff and Edmonton. *Manitoba:* Aweme. *New Brunswick:* Nictor Lake. *South Dakota*: Black Hills.

One hundred and forty-two specimens were studied before preparation of the above description. In the original description Swaine designated a female as the type; however, a male was described and was labelled as the female type in the Canadian National Collection. The above description of the female is based on Swaine's allotype, which was described as the male; the description of the male is based on the type.

Carphoborus bifurcus Eichhoff

Figs. 6, 7

Carphoborus bifurcus Eichhoff, 1868, Berlin. Ent. Zeit. 12: 147; Chapuis, 1869 Synopsis des Scolytides, p. 41 (1873, Mem. soc. roy. sci. Liége, ser. 2, 3: 249); Leconte, 1876, Proc. Amer. Philos. Soc. 15: 383; Schwarz, 1888, Proc. Ent. Soc. Washington 1: 80; Blatchley and Leng, 1916, Rhynchophora of North Eastern America, p. 660; Blackman, 1922, Mississippi Agr. Expt. Sta. Tech. Bull. 11: 49; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 128.

Dendroctonus bifurcus, Zimmerman, 1868, Trans. Amer. Ent. Soc. 2: 148.

Carphoborus bicristatus Chapuis (new synonymy), 1869, Synopsis des Scolytides, p. 41 (1873, Mem. soc. roy. sci. Liége, ser. 2, 3: 249); Leconte 1876, Proc. Amer. Philos. Soc. 15: 384; Blatchley and Leng, 1916, Rhynchophora of North Eastern America, p. 661; Blackman, 1922, Mississippi Agr. Expt. Sta. Tech. Bull. 11: 49; Chamberlin, 1939, The Bark and Timber Beetles of North America, p. 128.

This species is allied to *carri* but is really distinguished by the very strongly elevated interspace three on the declivity, which continues after joining interspace nine to interspace one; by interspaces five and seven, which end separately; and, in the female, by the slightly convex, granulate frons, which has shorter vestiture.

Female.—Length 1.4-1.8 mm., 2.5 times as long as wide.

Frons weakly convex, transversely impressed above epistoma, epistoma slightly elevated, the margin medially produced in front of mandibles; surface granulate; vestiture rather short, coarse. Antennal club 1.3 times as long as wide, the sutures straight.

Pronotum 1.2 times as wide as long; sides arcuately converging toward the rather broadly rounded anterior margin; surface coarsely, closely, rather shallowly punctured; median line not indicated; vestiture consisting of abundant small, erect, subcircular scales.

Elytra 1.9 times as long as wide; sides subparallel on basal two-thirds, appearing narrowly subtruncate behind; posterior profile altered conspicuously by the elevated declivital interspaces; basal margins elevated and armed with about nine large, overlapping crenulations; striae slightly impressed, the punctures very large, deep, close; interstriae much narrower than striae, weakly convex, the punctures confused, close, deep, rather coarse, often subgranulate. Declivital interspace (Figs. 6, 7) two very narrow, one slightly wider and feebly elevated; three wider than one, very strongly elevated; five indistinctly elevated and terminating separately from the more strongly elevated seventh; nine moderately elevated; one (very finely), three, five, seven, and nine serrate. Vestiture consisting of

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rather large, abundant, semi-erect, interspacial scales, each scale slightly longer than wide, some appearing almost multilamellate.

Male.—Similar to female except: frons more strongly convex above, more broadly impressed below, the surface more coarsely punctured, often with a small median elevation.

Type Locality.—"Amer. bor." Evidently "Carolina" according to Chapuis (1869, p. 41).

Hosts.—*Pinus echinata, P. taeda* and *P. virginiana.*

Distribution.—Southeastern United States, north to New York and west to Missouri and Mississippi. Specimens from the following localtities were examined. *District of Columbia:* Washington. *Florida:* Tallahassee. *Maryland*: "Md.". *Mississippi*: Agricultural College and Meridian. *Missouri*: Eminence. *New York:* Flatbush (Long Island) and Westpoint. *North Carolina:* Chadbourn, Raleigh, and Tryon. *Tennessee:* "Tenn.". *Virginia:* Arlington. *West Virginia:* Kanahwa Station.

Type material of *bifurcus* and *bicristatus* was not accessible. The type localtities of both are in the southeastern United States (Chapuis, 1869, p. 41, gives "Carolina" for *bifurcus;* Leconte, 1876, p. 384, gives "Georgia" for *bicristatus*). Since the 182 specimens examined from that region represent only one species, it is presumed, after careful study of the original descriptions, that these names apply only to different sexes of the same species, as was originally suggested by Leconte.

Acknowledgments

The author wishes to express his sincere thanks to the folowing individuals and their institutions for arranging the loan of specimens used in this study: Dr. W. H. Anderson, Section of Insect Identification and Parasite Introduction, U.S. Department of Agriculture, Washington; Mr. E. A. Chapin, U.S. National Museum, Washington; Dr. J. N. Knull, Ohio State University, Columbus; Mr. H. B. Leech, California Academy of Sciences, San Francisco; and especially Dr. T. O. Thatcher, Colorado Agricultural and Mechanical College, Fort Collins, with whom the author collected extensively in the western states. Thanks are also due Mr. W. J. Brown, Systematic Entomology Unit, Ottawa, for comparing specimens used in this study with the type of *simplex* Leconte.

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(Received October 26, 1954)

A Method for the Sterile Culture of Housefly Larvae, *Musca domestica* L.

By BERNARD GREENBERG[1,2]

During the past decade, larvae of the housefly, *Musca domestica* L., have been reared routinely in a medium containing two parts of wheat bran and one part of alfalfa meal, moistened with a yeast suspension and a solution of malt extract. The recent appearance of a standard mixture of wheat bran (33.3 per cent), alfalfa meal (26.7 per cent), and brewers grain (40.0 per cent), called CSMA (formerly NAIDM)[3], has further simplified the rearing of this species of fly. This note reports a modification of the CSMA medium and its use in the sterile culture of housefly larvae.

We have reared housefly larvae routinely for the past year in CSMA moistened solely with tap water. Approximately 400 cc of CSMA in a quart canning jar are thoroughly mixed with 300 cc of tap water, eggs are then introduced, and the jar is placed at 36°C. It is interesting to note that temperatures in the interior of the larval medium rise to 41°C or 42°C during the period of active growth. Seven different strains of flies were used, including some resistant to DDT. Two different lots of CSMA were employed. The developmental period was about 9 days, 4 days for the larvae and 5 for the pupae. Adults were of normal size, with a preoviposition period varying between 4.5 and 6 days, and laid fertile eggs.

During the course of studies on proteolytic enzymes in the housefly, it was found necessary to rear larvae under sterile conditions. The following method was used: Several 125 cc Ehrlenmeyer flasks, containing about 60 cc of CSMA moistened with 50 cc of tap water were plugged and incubated at 36°C for 24 hours. Ten cc of water were then added to each flask and the flasks autoclaved for 2 hours at 118°C. Eggs were disinfected by Glaser's method (1938) using White's solution, and about 50 eggs were introduced into each flask. Sterility tests were run for eggs and medium at this time, using thioglycollate broth which was incubated at 36°C and held for 48 hours. Aluminum foil was used to cap the cotton plugs of the flasks which were then incubated at 36°C. The control consisted of the unautoclaved medium with treated eggs in a flask similarly plugged.

At the end of 3 days, test maggots were in the 2nd instar and from 3 to 4.5 mm. in length, while the controls were mature 3rd instars, about 11 mm. long. The latter pupated on the fourth day and the test larvae pupated on the sixth day. Maggots in 3 of 5 flasks died as mature 2nd instars without further development; those in another flask died suddenly in an unaccountable manner as almost mature 3rd instars; while those in the last flask pupated in the cotton plug giving rise to undersized pupae. Fully formed flies began appearing 6 days after pupation so that the minimum developmental period was 12 days. Additional sterility tests on the fifth and seventh days showed the maggots and medium to be sterile. One flask, in which the maggots had grown as rapidly as the controls, proved contaminated.

These experiments were then repeated using larval media that had been incubated for 48 hours at 36°C, and another batch that had not been incubated

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2This investigation was supported in part by a grant, E-629, from the Division of Research Grants, National Institutes of Health, Public Health Service.

3A product of the Ralston-Purina Co., St. Louis, Mo.

at all, but was autoclaved as soon as it was prepared. The table summarizes the results of these experiments. With a 2 day incubation, larvae grew as rapidly as the controls and pupated in slightly less than 4 days. These pupae were of normal size. The larvae in the unincubated medium grew slightly during the first several hours after their emergence. Thereafter growth ceased and they continued to wander about in the flasks until they died, 3 to 7 days after hatching, still in the first instar. Presumably microorganisms and/or vitamins and other accessory food substances produced by the microorganisms during the incubation period and not destroyed by autoclaving are responsible for these results.

Incubation period (hours)	Number of flasks with pupae
0	0/6[4]
24	1/6
48	5/5

This simple method for rearing housefly larvae aseptically is not a substitute for a defined synthetic medium where the effect of known constituents may be significant. Where this is not important, however, the easy preparation and low cost of this medium recommend its use in more controlled studies of the housefly. For example, it is desirable in the study of maggot enzymes to eliminate any possible effect due to enzymes produced by the normal flora of the gut. This medium also provides the means whereby investigations can be undertaken to determine what effect, if any, the presence or absence of the normal gut flora have on the survival of certain enteric pathogens.

After the preparation of the manuscript, it was learned that G. S. Fraenkel and V. J. Brookes, Department of Entomology, University of Illinois, have obtained similar results.

Reference

Glaser, R. W. 1938. A method for the sterile culture of houseflies. *Jour. Parasit.*, 24: 177-179.

[4]Only 4 maggots reached the 2nd instar, and 2 of these emerged as bacteria-free adults 13 days after hatching.

THE RUNGE PRESS LIMITED, OTTAWA
Mailed: Wednesday, December 15, 1954